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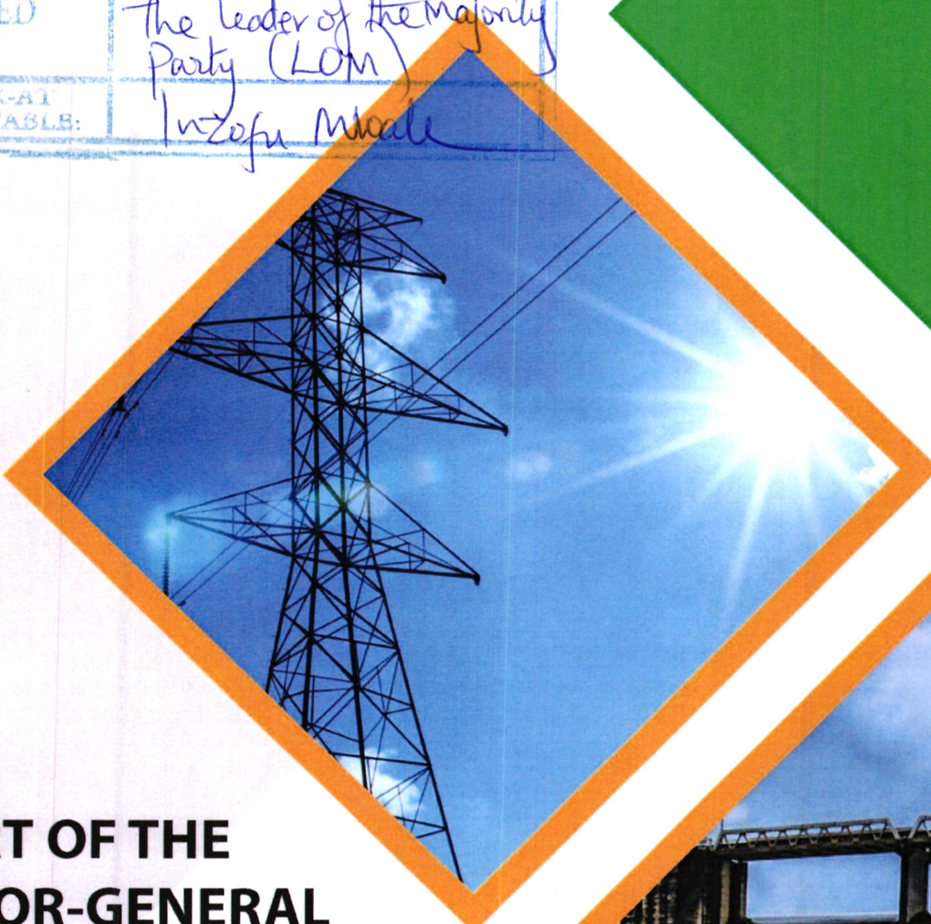

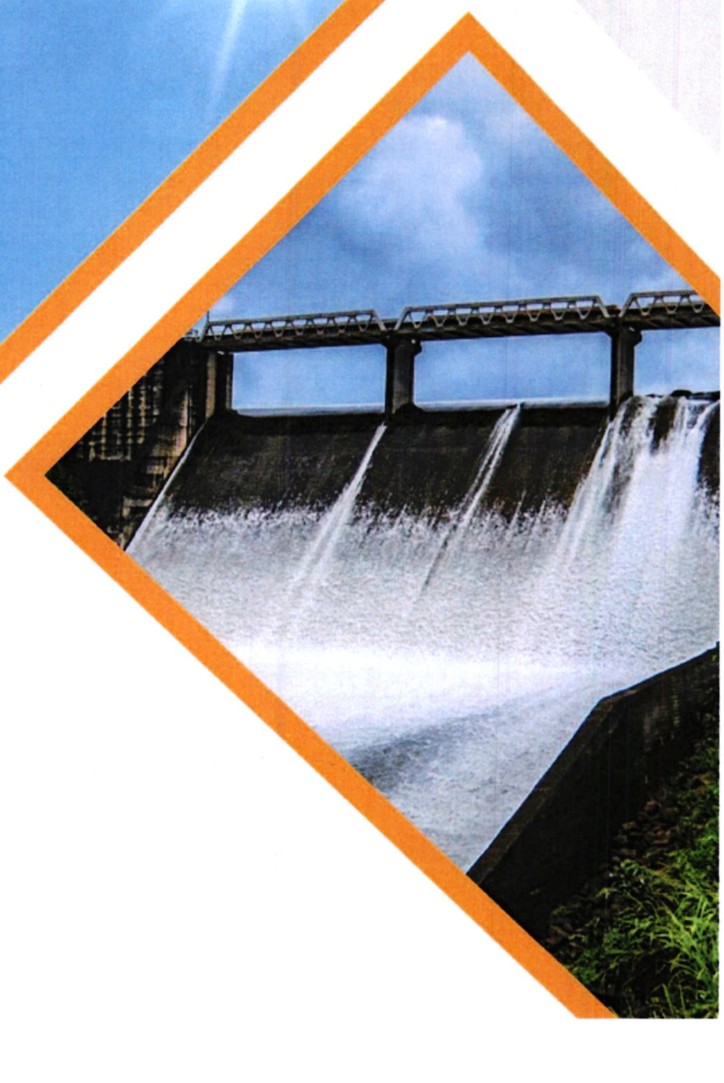

REPORT OF THE AUDITOR-GENERAL ON FORENSIC REVIEW OF POWER SUPPLY SYSTEMS LOSSES

KENYA POWER AND LIGHTING COMPANY PLC

24 FEBRUARY, 2023

Contents

Glossary of terms

Term	Definition
ABC	Aerial Bunch Cable
AEML	Adani Electricity Mumbai Limited
Ag	Acting
AMI	Advanced Metering Infrastructure
AMISP	Advanced Metering Infrastructure Service Provider
AMR	Automatic Meter Reading
AT&C	Aggregate Transmission and Commercial
ATM	Automated Teller Machine
BPDP	Bangladesh Power Development Board
BRPL	BSES Rajdhani Power Limited
BSPs	Bulk Supply Points
CAPEX	Capital Expenditure
CEO	Chief Executive Officer
CESC	Calcutta Electric Supply Corporation
CMRI	Common Meter Reading Instrument
CRM	Customer Relationship Management
CSC	Consumer Service Centre
CT	Current Transformer
DCU	Data Concentrator Unit
DESCO	Dhaka Electric Supply Company Ltd.
DGVCL	Dakshin Gujarat Vij Company Ltd
DISCOM	Distribution Company
DMS	Distribution Management System
DSCVO	Director of Security & Chief Vigilance Officer
DTR	Distribution Transformer
DWO	Disconnection Work Order
EA	Energy Audit
EBPP	Electronic Bill Printing & Payment
EEU	Ethiopia Electric Utility Company
EMI	Equated Monthly Instalment
EPRA	Energy and Petroleum Regulatory Authority
EPZ	Export Processing Zones
ERC	Energy Regulatory Commission
ESM	Energy Standard Meter
Est	Estimate
FDB	Facilities Database
FOREX	Foreign Exchange
GEB	Gujarat Electricity Board
GIS	Geographical Information System
GM	General Manager
GOK	Government of Kenya
GPRS	General Packet Radio Service
GVCL	Gujarat Vij Company Ltd.
GWh	Gigawatt Hour
HES	Head End Systems
HH	Handheld
HHD	Handheld Device
HHT	Handheld Terminal
HT	Hight Tension

Term	Definition
HVDS	High Voltage Distribution System
IBOS	Integrated Billing On Site (Meter Reading Application)
ICT	Information and Communication Technology
IEA	International Energy Agency
IMPS	Immediate Payment Service
IMS	Interruption Management System
InCMS	Integrated Customer Management System
IPPs	Independent Power Producers
IPS	Indian Police Service
IR	Infrared
IRDA	Infrared Data Association
IS	Indian Standards
ISBM	Integrated Spot Billing Machine
ISO	International Organization for Standardization
IT	Information Technology
IVR	Interactive Voice Response
KenGen	Kenya Electricity Generating Company
KEPCO	Korea Electric Power Corporation
KES	Kenyan Shilling
KETRACO	Kenya Electricity Transmission Company Limited
KPI	Key Performance Indicator
KPLC	Kenya Power and Lighting Company Plc
kV	Kilovolt
kVA	Kilo Volt Ampere
kW	Kilowatt
LECO	Lanka Electricity Company
LLF	Loss Load Factor
LT	Low Tension
LTWP	Lake Turkana Wind Power
LV	Low Voltage
MD	Managing Director
MDMS	Meter Data Management System
MGVCL	Madhya Gujarat Vij Company Ltd
MPAN	Metering Point Administration Number
MPMKVVCL	Madhya Kshetra Vidyut Vitaran Company
MRD	Meter Reading Data
MRI	Meter Reading Instruments
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MT	Metric Tonne
MV	Medium Voltage
MW	Megawatt
NCC	National Control Centre
NCSC	New Construction Service Center
NEFT	National Electronic Funds Transfer
NEO	Net Electrical Output
NSC	New Service Connection
NYS	National Youth Service
OAG	Office of the Auditor General
OMS	Outage Management System
OTP	One Time Password
PDA	Personal Digital Assistant
PDS	Permanent Disconnected Services

Term	Definition
PF	Power Factor
PG&E	Pacific Gas and Electric Company
PPAs	Power Purchase Agreements
PT	Potential Transformer
PTOF	Process Technology Organisation Facility
PwC	PricewaterhouseCoopers Limited
QA	Quality Assurance
RCM	Revenue Cycle Management
REA	Rural Electrification Authority
REREC	Rural Electrification and Renewable Energy Corporation
RF	Radio Frequency
RfP	Request for Proposal
ROW	Right Of Way
RPIC	Revenue Protection in Charge
RPU	Revenue Protection Unit
RT-DAS	Real Time Data Acquisition System
RTGS	Real Time Gross Settlement
RTUs	Remote Terminal Units
SAP	Systems Applications & Products
SCADA	Supervisory Control and Data Acquisition
SIM	Subscriber Identification Module
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SMS	Short Message Service
SOP	Standard Operating Procedure
T&D	Transmission and Distribution
TF	Task Force
ToR	Terms of Reference
ToU	Time of Use
TPDDL	Tata Power Delhi Distribution Limited
TSSPDCL	Telangana State Southern Power Distribution Company Ltd.
UGVCL	Uttar Gujarat Vij Company Ltd
UK	United Kingdom
USA	United States of America
USSD	Unstructured Supplementary Service Data
VAT	Value Added Tax
WARMA	Water Resources Management Authority
WO	Work Order

Executive Summary

1. EXECUTIVE SUMMARY

1.1 Introduction

1.1.1 His Excellency the President through a Special Gazette Notice No. 3076 published on 29 March, 2021 appointed a Taskforce to undertake a comprehensive review and analysis of all Power Purchase Agreements (PPAs) entered into between Kenya Power and Lighting Company PLC ("KPLC") and Independent Power Producers ("IPPs").

1.1.2 The aim of the Taskforce was to develop a suitable strategy for engagement with the Independent Power Producers and lenders, in order to achieve relief to electricity consumers and ensure long-term viability and sustainability of the energy sector.

1.1.3 The Taskforce concluded its work and submitted a report to His Excellency the President on 29 September, 2021. The report contained nine (9) key recommendations, among them, the need to undertake a forensic audit review on power supply system losses.

1.1.4 The Management of KPLC through the Principal Secretary, Ministry of Energy requested the Auditor-General to conduct a forensic audit review on power supply system losses in line with the recommendations and Terms of Reference defined of the Taskforce.

1.1.5 The Forensic audit review was conducted by PricewaterhouseCoopers Limited ("PwC") on behalf of the Auditor-General, focusing on large commercial consumers to establish if power delivered was consistent with the metered power, and that there is no power leakages.

1.2 Terms of Reference

1.2.1 The Terms of Reference for the forensic audit review as set out by the Taskforce were to:

i. Ascertain the energy accounting processes.

ii. Assess the adequacy of the energy metering, reading, billing and revenue collection standards and procedures.

iii. Test the design and effectiveness of controls in place to detect any likely non-accounting of sales.

iv. Unearth any fraudulent practices and recommend the necessary deterrence measures.

v. Quantify the exposure or loss to Kenya Power from such fraud and anomalies.

vi. Assess KPLC's institutional capacity to deal with existing and emerging system efficiency issues and recommend areas of improvement.

1.3 Approach of the Forensic Review

1.3.1 In line with the objective of the forensic audit review sought to establish the cause and extent of power losses at KPLC and investigate cases where the losses appeared to result from cases of irregularities.

1.4 Key Findings

Overview and management of system losses

1.4.1 There was lack of ownership, accountability, dedicated resources, and a coordinated approach in the accounting of energy.

1.4.2 System losses comprise of technical and commercial losses. Technical losses are power losses that occur within the infrastructure used for power transmission and distribution while commercial losses arise from commercial factors such as incorrect meter readings, unmetered consumption, and power theft.

1.4.3 In determining both technical and commercial losses, KPLC relies on a combination of meter readings, partial modelling or simulation of the grid using a software and estimates based on historical loss study reports. These commercial and technical loss calculations are often prone to errors.

1.4.4 As at March 2022, the total system losses were about 22.64%, out of which 12.12% and 10.52% were technical and commercial losses, respectively. This is according to KPLC management data and analysis

1.4.5 The table below summarises power purchases, sales, and estimated losses resulting the power supply systems over a period of eight (8) years between 2014 to 2022. The analysis is based on energy data received from KPLC presented in Gigawatt hour ("GWh")

Category	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22*
Units Purchased	9,280	9,817	10,205	10,702	11,491	11,462	12,102	11,578
Units Sold	7,655	7,912	8,272	8,459	8,769	8,773	9,203	8,949
System Losses (GWh)	1,625	1,905	1,933	2,243	2,722	2,689	2,899	2,629
System Losses (%)	17.5%	19.4%	18.9%	21.0%	23.7%	23.5%	24.0%	22.7%
Loss Movement (%)		1.9%	-0.5%	2.0%	2.7%	-0.2%	0.5%	-1.2%
Est Losses (KES M')**	12,464	14,611	14,826	17,204	20,878	20,625	22,235	20,164
Est Loss Movement (KES M')		2,148	115	2,477	3,674	-253	-1,611	-2,071

1.4.6 Technical losses are caused by dissipation of power in the infrastructure used for transmission and distribution. In the context of KPLC and other power distributors, the main drivers of technical losses are transmission lines, feeders, and transformers used in transmission and distribution of power in terms of conductor length and size, power load levels, specifications, and type of equipment used among others.

1.4.7 KPLC undertook various initiatives and projects which could have contributed to the increase of the technical losses in the recent years. Those initiatives include rapid expansion of the grid to support rural electrification projects, commissioning of the Lake Turkana Wind Power ("LTWP") and Olkaria V generation plants, and their associated transmission lines.

1.4.8 Commercial losses arise because of factors such as incorrect meter readings, unmetered consumption, and power theft. In the KPLC context the commercial losses could occur at generation, transmission, and distribution levels.

1.4.9 Commercial losses in the distribution network are mainly attributable to meter miscalibration and errors, meter tampering, illegal connections and meters and incorrect meter readings among others.

1.4.10 Growth in KPLC institutional capacity to monitor the customers has not been in tandem with the pace of the customer expansion. This was attributed to difficulties in hiring technical staff, indicating that staff recruitment proposals to the Board did not materialise.

1.4.11 Kenya Power shifted majority customers, especially in urban centres to prepaid meters. While this shift was intended to and may have reduced the operational costs associated with meter reading, it elevated the risk of power theft. Since under the pre-paid regime, KPLC does not frequently visit customer premises for meter reading, meter bypasses and other malpractices leading to power losses may therefore go undetected.

1.4.12 In addition, the rural electrification projects which form the bulk of the customer base expansion are largely implemented through the Rural Electrification and Renewable Energy Corporation ("REREC"), an independent Government Agency. Connections by REREC poses a commercial loss risk to KPLC. This is because of delayed metering after REREC connects the customers.

1.4.13 Comparison of the distribution losses with other power distribution utility companies in India, Bangladesh, Sri Lanka, and the USA revealed that companies with a similar consumer profile as KPLC were performing better than KPLC and had lower losses as shown below:

Utility	Country	Geographical area (Sq.km)	Total Consumers (m)	Distribution Loss (FY 21)
KPLC	Kenya	582,646	8.2	23.95%
TPDDL	India	52,000	9.3	6.83%
TSSPDCL	India	510	1.8	19.91%
MSEDCL	India	307,713	27	13.09%
MPMKVVCL	India	96,069	4.9	27.6%
BRPL	India	750	10	7.28%

DGVCL	India	23,307	3.2	6.73%
Torrent	India	120	1.9	5.5%
AEML	India	400	2.1	7.37%
BPDB	Bangladesh	34,827	3.3	8.99%

1.4.14 Over the years KPLC has implemented various loss reduction initiatives, key among them, building of additional substations to boost voltages and installation of feeder metering. However, the initiatives do not appear to have achieved the desired outcomes due to lack of proper structure around the initiatives such as metering, lack of follow up and budgetary constraints.

1.4.15 Generally, there was lack of ownership and coordinated approach to power system losses across the Company which undermines the effectiveness of the loss reduction initiatives.

System Losses in the Generation and Transmission Network

1.4.16 There is no accounting of energy movements after purchase but before sale (transmission and distribution) at nascent stages (i.e., there is no proper energy balance analysis). This is where the most significant risk of system losses lies.

1.4.17 There is possible miscalculation of losses due to the use of outdated loss study reports, partial simulations, and arithmetical errors.

1.4.18 KPLC assumes that all the power losses occurring in the transmission network are technical in nature. However, some of the losses are commercial in nature attributable to local and exports customers connected to the transmission grid, and over-reporting of power that is injected into the transmission lines at the generation plants.

1.4.19 As at the time of review in May, 2022, KPLC had connected twenty-two (22) large power customers to the transmission grid who were consuming approximately 418 GWh of power annually or 3.5% of the power purchased. The review revealed that eleven (11) large power customers did not report consumption in the period between July, 2020 to June, 2021. However, KPLC Management did not investigate the reasons for non-consumption by those customers.

1.4.20 The forensic audit review revealed that KPLC does not breakdown losses per transmission line. As a result, transmission lines with high losses are not identified to inform suitable loss reduction measures. Further, losses arising from transmission lines, if accurately determined, can be attributed, and be borne by Kenya Transmission Company Limited ("KETRACO").

1.4.21 There were weaknesses identified at generation substations which included lack of check meters, faulty check meters and discrepancies between the check meters and main meters. Power Purchase Agreements ("PPAs") between

KPLC and power generators provides that a generation plant should have a main meter and a back-up meter (check meters) for corroborative meter readings.

1.4.22 Main meters are owned by power generators while the check meters are owned by KPLC. However, out of the ninety-six (96) generation plants supplying power to KPLC, only thirty-eight (38) or 40% had check meters. In addition, the thirty-eight (38) plants with check meters were all off-grid power stations.

1.4.23 The forensic audit review further revealed that check meters in nineteen (19) plants were either off, blank or their readings had not been taken and recorded which indicates poor maintenance practices of the check meters by KPLC.

1.4.24 Metering deficiencies were identified at the transmission substations and Bulk Supply Points ("BSPs") where power is stepped down for dispatch into the distribution network. The deficiencies included BSPs not metered, faulty meters and lack of metering data for transmission substations under KETRACO. The deficiencies hindered accurate determination of the power getting into the distribution network which affects the accuracy of the computed transmission and distribution losses.

1.4.25 KPLC computes transmission losses using a set methodology. To test accuracy of losses computation, three transmission lines comprising of the 220 kV Turkwel – Lessos line, the 220 kV LTWP (or "Loiyangalani") – Suswa line and the 132 kV Kegati - Awendo – Ndhiwa line were sampled and losses in those lines recomputed for comparison purposes. The re-computation revealed that Turkwel – Lessos line loss of 4.23% was lower than the deduced loss of 4.39%. However, the reported loss by KPLC was lower since it did not exclude energy purchased from Turkwel generation plant and distributed to the local area at 11kv and back feed energy along the transmission lines at the Cedate and Selenkei generation plants.

1.4.26 Additionally, LTWP – Suswa transmission line and Kegati – Awendo - Ndhiwa transmission lines recorded losses of 5.99% and 7.07% respectively, which were higher than the KPLC average transmission loss of 4.02%. Further, the analysis revealed a system loss of 13.8% at Kegati substation, which translated to about Kshs.11million per month. The Management attributed the losses to metering errors at the feeders exiting the substation.

System Losses in the Distribution Network

1.4.27 Technical and commercial losses in the distribution network averaged 7.94% and 10.52% respectively. The review established that KPLC derives technical losses through a combination of simulations and estimates based on a 2015 losses study report by a consultant engaged by the Management. The simulation entails use of a software which computes the expected loss based on the known profile of Medium Voltage ("MV") feeders and Low Voltage ("LV") feeders.

1.4.28 The approach implies that inaccuracies in the transmission network loss simulation and estimation of technical losses at the distribution level will have an impact on the derived commercial losses.

1.4.29 There were gaps identified throughout the distribution network which impaired KPLC's ability to monitor and effectively address distribution losses. The gaps included failure to determine losses in particular areas or feeders, lack of focus on internal meters, lack of a system or structured mechanism of taking feeders and transformer meter readings, recording, and analysing meter readings.

1.4.30 KPLC does not have access to metering data from Kenya Electricity Generating Company PLC ('KENGEN") operated bulk distribution points and stations which are critical for loss calculations.

1.4.31 There are notable delays in metering of new customers, especially those under REREC due to inadequate information exchange protocols.

1.4.32 There are significant number of administrative counties and feeders which were not metered. Review of KPLC administrative counties revealed that forty (40) out of the forty-nine (49) counties equivalent to 77% were not metered. Similarly, only two hundred and fifty-five (255) or 67% of three hundred and seventy-six (376) primary substations and seven hundred and three (703) or 70% out of one thousand (1,000) feeders were not metered. This hinders loss determination and remediation initiatives. The above implies that KPLC is neither able to hold staff in counties accountable for the power received in counties nor able to come up county specific loss reduction initiatives.

1.4.33 In 2015, KPLC initiated the Advanced Metering Infrastructure ("AMI") project otherwise known as smart metering which targeted large customers with the objective of revenue protection since smart meters are considered more accurate, have advanced tamper proof features and can be disconnected and reconnected remotely in case of customer default. However, during the review, it was revealed that out of 8,205 large power customers, 1,609 customers or 19% were not on smart meters. Having large customers on manual meters undermines the objective of the smart metering project, particularly revenue protection.

1.4.34 Some of the KPLC meters are of higher classes hence lowers the accuracy of power consumption measurements. The customer meters are spread across classes 0.2S, 0.5S and 1.0S. A class 0.2S meter has a 0.2% margin of error and is thus more accurate than a class 1.0S meter that has a margin of error of 1%. Review of a sample of large customers revealed five (5) cases where meter readings were lower than the logged energy readings by a factor of more than 1%, meaning the meters registered low measurements compared to the loggers.

1.4.35 An analysis of distribution losses in sub-regions and feeders revealed that losses in some feeders were significantly high while on others, the loss was lower than expected, and in some cases falling in the negative. Of the eight (8) KPLC administrative regions, South Nyanza had the highest system loss by percentage, averaging 44.69% between 2020 and 2022. According to KPLC, South Nyanza regional team, the losses were attributable to misplaced customer meters which are mapped to different counties, and heightened power pilferage in the region attributable to unmetered connections and meter bypasses.

1.4.36 An independent measurement of the consumption in thirty-two (32) large power consumers for an average of seven (7) days revealed adverse variances between the customer installed meter readings and the logger readings. More than 50% of the logged customers showed a variance of more than 1%. Further, 10% of the logged sites reflected a variance above 3%. While KPLC allows for a maximum error of 3%, at least one third of the customers measured had a positive variance meaning their meters recorded a higher consumption than the loggers as shown below:

Voltage Level	Tariff	No of Customers	0-+/-1%	+/-1-+/-3%	Above +/-3%	Unclassified
132 KV	CI5	1	1	0	0	0
66 KV	CI4	4	0	4	0	0
33 KV	CI3	4	0	4	0	0
11KV	CI2	17	7	5	4	1
415	CI1	6	5	1	0	0
Total		**32**	**13**	**14**	**4**	**1**

1.4.37 Discrepancies of up to -81.4% in one of the cases, between independently measured power usage and the KPLC meters were identified at a sample of large commercial customers reviewed.

1.4.38 An analysis of the customers billing data revealed several unusual patterns and anomalies that pointed to possible unbilled usage by consumers which would contribute to the overall system losses as shown below:

i Increase and decrease in power consumption across comparable periods.

ii Variances between expected consumption and actual consumption following peer-to-peer analysis.

iii Significant increase in power consumption after installation of smart metres.

Effectiveness of Existing Controls in Detection of Non-Accounting of Sales

1.4.39 Customer usage exceptions and significant variations are calculated but not investigated to a logical conclusion to allow consideration of appropriate remedial measures. Most exceptions are closed as production related without thorough investigations.

1.4.40 There is lack of adequate equipment to aide in the usage audits and inspections. For example, KPLC has less than 10 clamp meters and power loggers country wide

1.4.41 There are limited or no follow through of issues identified during internal audits.

Processes and Practice Improvement Opportunities

1.4.42 KPLC has about 8.7 million metered consumers. About 6.6 million of these consumers are on prepaid meters and the other 2.1 million consumers are on post-paid meters. As of February 2022, KPLC had about 8,200 large power consumers i.e., consumers whose consumption is above 15,000 kWh per month. Large consumers are on post-paid meters with 80% of those on smart meters and the rest on Automatic Meter Reading ("AMR"). AMR meters require manual meter reading since their communication platform is obsolete while smart meters can be administered remotely and have the capability of transmitting meter readings to a central server. However, the smart meters were read manually when their communication function was not working.

1.4.43 For large power consumers on AMR meters and non-communicating smart meters, meter readers take readings manually through handheld terminals. The leading industry practice is to use technologies like Meter Reading Instruments ("MRI") for accurate meter reading, especially for high value consumers. MRI captures various parameters apart from consumption-power factor, tamper, load profile among others.

1.4.44 Data Analytics tests on KPLC's billing data revealed meter reading inconsistencies where 1,762 instances of large power accounts had zero or no meter readings for either the High-Rate or Low-Rate units. The inconsistencies were attributed to wrong meter readings due to erroneous data entries by KPLC meter readers, faulty meters, and reading estimations.

1.4.45 Several customers had long outstanding and uncollected debts. For instance, 110 large customer accounts had underpaid/unpaid outstanding bills of more than 360 days totalling to Kshs.1.5 billion, of which, 72 with underpaid or unpaid bill amounting to Kshs.383 million were active.

Weaknesses, Implications, and Responsible Offices

1.4.46 The forensic audit review identified the following weaknesses with corresponding implications and responsibilities as indicated below:

S/No.	Shortcomings	Implication	Responsible Offices/ Department/ Directorates	Recommendations
1.	Unusual losses and consumption anomalies by some large customers	Possible commercial losses	General Manager, Commercial Services	Investigate the cases highlighted in the Report further including interviews with the customers. This will help conclude on the culpability of specific officers that were responsible for the losses. Broaden the scope of review/investigation beyond the sample customers reviewed
2.	19% of large consumers do not have smart meters. Some of these were still large customers when the smart metering project began.	Inability to detect malpractices such as meter bypasses or other types of interventions that would otherwise be reported by the smart meters.	General Manager, Commercial Services	Install smart meters at all large customers. Investigate consumption exceptions that may arise after installation of smart meters. Where exceptions are noted and it is likely that the lack of smart meters allowed the anomalies to persist, investigate whether the non-installation of the meters was deliberate and if so, assess culpability of the officers involved.
3.	Reduced customer vigilance after the installation of smart and pre-paid meters.	Inability to monitor, deter and detect system losses	General Manager, Commercial Services	Redesign the vigilance and inspection mechanisms to reflect the operating procedures under smart and pre-paid meters as recommended in this report.
4.	Rapid growth in the customer base in the last 10 years (70%) not matched with proportionate internal capacity enhancement of the field inspection teams.	Inability to monitor, deter and detect system losses	The Board of Directors and Senior Management	Enhance the internal capacity to match the increased customer base by way of personnel and tools

1.5 Conclusion and Recommendations

1.5.1 Due to the several control gaps identified during the review, particularly the absence of robust loss identification mechanisms, KPLC has not instituted corresponding recovery mechanisms from customers.

1.5.2 The report proposes areas and procedures that will enable KPLC gain a better understanding of the system losses and the interventions needed from Management need to make to reduce the power supply systems losses.

1.5.3 To effectively implement the recommendations, KPLC should consider dedicating a senior management level staff tasked to focus on system losses reduction equipped with necessary tools and resources. Further, KPLC should consider establishing an Accountability Framework Across the organisation focusing on power losses. Where these already exist, they should be enforced to ensure that loss reduction is prioritised.

1.5.4 The approaches adopted by KPLC in identification and management of system losses need to be enhanced by data analytics and technology. Traditionally, KPLC has leaned more towards sample physical inspections, referred as 'sweeps' which are not necessarily informed by data analysis.

1.5.5 KPLC Management should assess the impact of large power consuming customers to the transmission losses and consider apportioning the transmission losses into commercial and technical categories.

1.5.6 Consumption anomalies revealed during the review at some large customers which could result to commercial losses should be investigated to enable KPLC institute suitable interventions.

1.5.7 Where the bulk supply points are at KETRACO substations, KPLC should work with KETRACO to ensure that all the meters are functioning appropriately for accurate measurement of energy and determination of losses.

1.5.8 Adverse variances between the customer installed meter readings and logger readings should be investigated to establish their cause and ascertain whether they are indicative of power underbilling.

1.5.9 KPLC should consider use of clamp power loggers which measure power directly on overhead power lines before customer installations since they are less susceptible to bypasses and information leakages.

1.5.10 Given the complexity of the grid, metering gaps and other challenges observed, the approach to system losses computations should be enhanced through initiatives such as complete modelling and simulation of the grid, installation of smart meters on the substations and feeders that are either not metered or not on smart meters, and proper mapping of customers to feeders. This will enhance the accuracy and reliability of the data and loss calculations.

1.5.11 Given that 1% loss of power translates to more than KES 2B loss, KPLC, should carry out thorough measurement of transmission losses to allow for a more accurate assessment of where the losses are arising from for more targeted interventions.

1.5.12 In the long run, a more reliable system 3for determining losses would entail the use of meters at all levels, complete simulation of the grid and a more accurate determination of the load levels using among other tools. Supervisory Control and Data Acquisition ("SCADA") system which, have capabilities to measure power in addition to load levels at various hand-over points.

There is need for KPLC Management to revaluate parameters used for determining power supply systems losses given the complexity of the systems, roles played by various players in the generation and distribution network, and weaknesses existing in computation of reported efficiency losses. The approach to system losses should be enhanced through use of technology and effective monitoring of power purchase and sales measurement to minimise commercial losses and improve accuracy of the data used in power supply systems loss computations.

CPA Nancy Gathungu, CBS
AUDITOR-GENERAL

Nairobi

24 February, 2023

Introduction

2. Introduction

2.1 Pursuant to our contract dated 28 September 2022, we are undertaking a Forensic Review of Power Supply System Losses at Kenya Power & Lighting Company Plc ("KPLC").

2.2 Our observations in this Report are based on specific procedures and analysis described herein and are based only on the information made available to us as of 30 September.

A. Objectives and scope

2.3 The key objective of the review is to assess the systems losses at KPLC with a focus on commercial losses attributable to large consumers. Specific objectives of the review are:

i. To carry out an assessment and quantify, to the extent possible, the level of technical and commercial losses in the system.
ii. To undertake comprehensive analysis of the Kenya Power's metering and billing processes and systems and other energy accounting methodologies used in order to ascertain their adequacy, identify any gaps and propose remedial measures.
iii. To review the current processes, initiatives and methodologies for technical and commercial loss reduction and assess their effectiveness.
iv. Assess the energy loss and fraud risks and where there is evidence of fraud in any of the processes establish the pervasiveness of the identified fraud risks.
v. Investigate specific identified cases of fraud and other irregularities with a view of quantifying the losses and establishing the *modus operandi* of the fraud and identify the responsible persons and parties.
vi. Specifically, perform a detailed technical audit of key commercial consumers for at least the last 3 years to ascertain if electricity delivered is consistent with what is metered and billed.
vii. To assess Kenya Power's institutional capacity to deal with existing and emerging system efficiency issues and identify potential areas of improvement.
viii. To identify the type of opportunities, initiatives and investments needed to bolster and support system loss reduction through a robust Framework of joint-action, benchmarking, technical collaborations and partnerships and other institutional capacity building approaches.
ix. To develop a clear and smart short-, medium-, and long-term Roadmap and Implementation Plan.

2.4 The review period was July 2018 to March 2022.

2.5 A mapping of the objectives to the category of findings in the report where they have been addressed is provided in the table below.

Note: A tick √ means that the objective is covered in the specific category of findings:

No.	Mapping of the TORs to the category of observations in the report	Overview and management of system losses	System losses in the generation and transmission network	System losses in the distribution network	Process and practices improvement opportunities
i.	Ascertain the energy accounting processes.	√	√	√	
ii.	Assess the adequacy of the energy metering, reading, billing and revenue collection standards/procedures.				√
iii.	Test the design and effectiveness of controls in place to detect any likely non-accounting of sales.				√
iv.	Unearth any fraudulent practices and recommend the necessary deterrence measures;		√	√	
v.	Quantify the exposure or loss to Kenya Power from such fraud and anomalies.	√	√	√	
vi.	Assess Kenya Power's institutional capacity to deal with existing and emerging system efficiency issues and recommend areas of improvement.				√

Table 27: Mapping of specific objectives to the relevant category of findings addressing them in the report.

B. *Work Done*

2.6 We conducted our review between 22 March 2022 and 30 September 2022. The review involved policy and procedure reviews, data analysis, review of various systems, discussions with various persons at KPLC as well as logging of selected large consumers' power usage.

2.7 The General procedures that we performed included:

i. We held a kick-off meeting with the management of KPLC and a representative from the Office of the Auditor General ("OAG") on 21 March 2022. Following the meeting, we set out the expectations of all parties involved, we were assigned contact persons and officially kicked off the review.

ii. Meetings with various departments to obtain an understanding of the systems in place as well as their roles in the power supply process. Specifically, we met with officers from the following divisions:

a. Commercial Services and Sales – To understand meter installation, reading, inspection, connection, reconnection, billing, and collection processes.
b. Regional Coordination – To understand the apportionment of power losses among various regions and counties.
c. Network Management – To understand how Kenya power determines power losses, the various systems involved in the process, the data required and the various network elements that relate to power losses.
d. Information Communication & Technology– to understand the various systems involved in metering, billing, and power management. We sought to understand the available data, the format and how to optimally obtain the data for our analysis.
e. Institute Of Energy Studies & Research – to understand the technical specifications of power loggers that we will use to log selected large consumers. The meter calibration technicians took us through the metering of test sites as well as how to download and analyse data from the power loggers.

We have included in the appendices minutes of the formal meetings that we held with key persons as listed below:

Appendix No.	Meeting
1	Notes from our meeting with Ms Cecilia Kalungu – General Manager, Human Resources and Administration
2	Notes from our meeting with Engineer Paul Mwangi Ag – General Manager Network Management
3	Meeting notes with Mr John Ihuthia Ag – General Manager, Power Planning and Purchases
4	Meeting notes of meeting with the SCADA team
5	Meeting notes of meeting with the Network Team
6	Notes from our meeting with Engineer Charles Mwaura – General Manager Network Management
7	Meeting notes for meeting with South Nyanza regional team
8	Notes from our meeting with Engineer Rosemary Oduor – General Manager, Commercial Services

During the engagement, we held routine day-to-day consultations and discussions with various stakeholders at KPLC to understand the processes and practices. These were not necessarily in a formal interview set up. These were not documented in the form of interview notes due to these informal setups. We have however provided the list of the persons that we spoke to in the preamble of the Report.

iii. We held further discussions with the Network team who took us through the process of calculating power losses. We discussed the principles and formulas applied, the various tools in use and the inputs to the process. The discussions covered;

a. Transmission power losses
b. Distribution power losses

c. Commercial power losses

iv. Review of the various reports regarding initiatives to address power losses undertaken by KPLC. These are summarised below.

Report Name	Report Area
Report Of The Presidential Taskforce On Review Of Power Purchase Agreements	Comprehensive review and analysis of the terms of all Power Purchase Agreements (PPAs) entered into by the Kenya Power and Lighting Company Limited (KPLC)"
Energy Loss Reduction Audit Report No. - Ra-04-2020/2021	Energy loss reduction focussing on feeders, border point metering and energy loss initiatives.
Revenue Assurance Audit – RA-2021/2022-01 Energy Loss Reduction	Energy loss reduction focussing on Transactions from July 2020 to June 2021
Technical Audit Report No.4 - 2021/2022 - Special Audit On Fdb/Gis Clean Up Project Implementation	NYS GIS data clean-up on Low Voltage infrastructure and Consumer meters for Kajiado, Kiambu, Machakos & Nairobi counties.
Revenue Assurance Audit - Ra2020/2021-05, Large Power Revenue Audit - Mt Kenya Region	Desktop audit of large power accounts transaction in Mt Kenya region.
Technical Audit Report No 072021/2022 GOK Funded last mile Projects	An audit on GOK Funded last mile projects.
Technical Audit Report No. 10 - 2020/2021- Special Audit On Zero Revenue Accounts	Audit of the complete data in InCMS of all nonvending, zero vend and zero consumption accounts. For AMI project the scope was the first 11,132 meters installed.
Large Power Audit – West Kenya Region: Technical Audit Report 2021/2022-03 and Revenue Assurance Report RA 2021/2022-02	Audit on Inaccurate Billing/loss of revenue through unbilled consumption, large power metering installations, C&I utilization and Debt management.
Technical Audit Report No 122020/2021 - Large Power Accounts Audit- Coast	Audit of the Billing anomalies, unsealed installations, Faulty/or tempering with metering equipment, Unsafe installations, Account Deposit/Bank Guarantee, C&I system utilization and resource utilization.
Technical Audit Report No 012020/2021 - Large Power Audit- Nairobi West and South Sub counties	The audit focused on the controls and mitigation measures in place to curb losses that can be incurred on large power installations from inaccurate billing and faulty installations.
Technical Audit Report No TECH2019-2020-09 analysis on large power account billing and exception reports	The key focus of the audit was on exception reports and billing records analysis
Technical Audit Report No 02 – 2021/2022 - Primary Substations Audit	Risk based audit on optimal utilization of substations, system flexibility, Maintenance of substations and feeder metering.
Technical Audit Report No 06 – 2019/2020 Street Lighting Installations – Nairobi west Sub- County and Kajiado county.	Audit focused on meter installation, meter reading, and alignment of meters in the correct coordinates in InCMS system.
Tetra Tech Report on system wise Energy losses study	Study was aimed at analysing system wide losses, capacity building and provision of cost-effective investment proposals to reduce losses.

Table 28: Initiatives reports reviewed

v. Sampling criteria for the independent power consumption measurement at 32 select customers

a. Using data analytics as well as our industry knowledge, we selected 32 large customers for power logging. These were mainly large power consumers in the CI class. Below is the summary of the analytics sampling criteria:

a-1) We conducted risk-based analytics to identify customers with inconsistencies as part of our targeted sample for logging. We identified customers that exuded the following features: Customers whose consumption exceeded 30% of their previous 3-month average consumption.

a-2) Customers in tariffs C1-C5 who's previous 3-month average consumption is consistently less than 15,000 units. Based on our analysis such customers should be moved to a lower tariff as they enjoy discounted rates yet not meeting thresholds set by KPLC.

a-3) Customers with frequent re-billings attached to their accounts. This is captured by filtering out accounts with negatives HR and LR unit readings as well as negative total bills.

a-4) Customers whose power factor surcharge contributed to more than 30% of the total bill. We filtered out customers with extremely low power factor ratio calculated as (Active Power<KVA>/Apparent Power<KW>)

a-5) Customers with high total bill variations after comparing the provided total bill in the large power dataset with our independent bill re-computation. We sampled customers with very high variation.

a-6) Customers whose consumption spiked after installation of smart meters. We picked out samples of customers whose consumption spiked then normalized after a few months plus customers whose consumption increased without a drop.

a-7) We used nine KPLC data loggers for the logging process. We understand that KPLC calibrated the loggers before handing them over. We underwent technical training at the KPLC's Institute of Energy Studies & Research to understand the technical specifications of the data loggers and their use. We subsequently developed a checklist that we used for the logging process and other general inspection activities at the consumer sites.

a-8) With the help of KPLC staff, we accessed the selected customers premises. Prior to logging, we undertook a general evaluation of the customer metering where we took note of:

i) The type of meter wiring
ii) The CT/PT ratios applied
iii) Smart or non-smart
iv) Meter Accuracy Class

b. We connected loggers to measure the same current and voltage signals into the meter from the current transformers and Potential Transformers and set them to log for an initial period of 30 minutes. We then compared the logged power usage to installed meter indicative usage to check for any discrepancies that could have been indicative of inaccurate logging.

c. Once we confirmed that the loggers were correctly set, we sealed the meter boxes, noting the serial number of the seals used. We then left the logger in place for about 7 days

d. After the end of the logging period, together with KPLC staff, we accessed the premises and broke the seals, noting the serial numbers. We then captured the installed meters readings and stopped the loggers.

e. We downloaded the logger data using Metrel Powerwave software from the data stored in the SD card and compared the energy consumption with the recorded energy consumption as per the installed meter.

vi. We reconciled power at various points across generation, transmission, and distribution points

a. We reconciled the energy from the point of dispatch to KPLC by the various generators to the energy that was eventually available for distribution at the bulk supply points.

b. We assessed the accuracy of calculations carried out by KPLC in relation to purchased energy and noted the metering gaps at the generation stations, transmission lines and bulk supply points.

c. To the extent possible, we computed transmission losses at a high level and conducted an energy balance analysis in the South Nyanza region.

d. At a high level and based on readily available information from SCADA and meter readings recorded in the *mrep* reports, we determined the technical losses in transmission lines.

e. We carried out a high-level analysis on the power consumption by customers connected to the transmission grid and highlighted irregular patterns noted.

vii. We reviewed KPLC technology landscape, obtained data and performed in-depth analytics on the billing data both large power and domestic consumers with an aim of identifying customers with unusual power consumption and billing patterns.

a. We reviewed the systems and processes in place at KPLC to measure and account for power as well as for billing including the computation inputs (primarily meter readings) and assumptions relied on by Kenya Power in Energy accounting for commercial and retail customers.

b. We picked out customers with significant increase and decrease of power consumption based on a three-month consumption analysis isolating customer with huge variances.

c. Using the smart meter master data provided, we isolated large customers whose consumption spiked immediately after installation or replacement of smart meters as well as customers with sustained increase post smart meter installation.

d. To the extent possible, we independently recomputed the large power customer bills for each billing cycle in the review period identifying customers with significant bill variances.

e. We performed a debt aging analysis in a bid to understand KPLC's revenue collection and debt aging patterns. We identified customers with either missing payments or long outstanding debts.

f. Additionally, we carried out an analysis of prepaid customers token purchases isolating customers with suspicious activities.

C. *Limitations*

2.8 The following general limitations are to be considered when reading and interpreting this report:

i) PwC has included information relevant to the review and related circumstances, but PwC cannot guarantee that all the information has been included, as the possibility exists that not all of the relevant information and documentation has been presented to PwC.

ii) In the event that additional information becomes available that could impact our findings, PwC reserves the right to review such records and reconsider/amend the findings set out in this Report.

iii) PwC makes no representation regarding questions of legal interpretation. PwC has not obtained any legal opinion concerning the matters outlined in this Report.

iv) It is PwC's practice to retain one copy of all data provided by its clients for PwC's own internal quality and compliance purposes.

v) No portion of the content of this Report may be quoted, referred to or disclosed, in whole or part, without PwC's prior consent in writing.

vi) We did not engage with third parties (outside of KPLC) regarding our findings due to scope limitations. A number of our findings will require that KPLC undertakes further work, including engagement with third parties such as customers. ***Specific Limitations***

2.9 During this engagement, we received cooperation and assistance from KPLC Management and staff. As a result, we were able to carry out the procedures set out in our scope of work. However, we experienced some challenges which affected the pace of the investigation and the extent to which we could carry out investigative procedures in some areas. We outline these challenges below.

i) Inadequate or lack of metering data

2.10 In the proposal that we submitted to KPLC on 3 December 2021, we envisaged that we would undertake the following procedures to meet the objectives of the assignment:

a) Independent validation of the calculations used by KPLC in arriving at the purchased energy.
b) Independently rework the energy accounting figures at the generation, transmission, distribution, metering and retailing levels.
c) Independent measurement of power consumption at select large consumers.
d) Use analytics to review the meter reading, billing/vending, prepaid token generation and bill adjustment processes and quantify any variances.
e) Identify any fraudulent practices using forensic analytics, quantify the exposure or loss to KPLC.
f) Discussions with responsible persons to obtain explanations for anomalies and gaps noted
g) Investigation into any noted cases of suspected fraud.

2.11 In our comments on the Terms of Reference ("ToRs") in the proposal we further anticipated and noted that:

a) Most of the work that we proposed to do would involve data analysis and review of metering equipment under the custody of KPLC.
b) Based on the broad nature of the scope and our experience in undertaking engagements of this nature, it was unlikely that requisite extensive engagement with third parties (especially commercial customers of interest) would be possible within the 60-day period. We noted that if we are unable to obtain certain key information, we would report it in the scope limitation section of our report.

2.12 Initially, we were to carry out the review within a period of 60-days. However, following discussions with KPLC and the Office of the Auditor General ("OAG") regarding delays in the provision of information by KPLC, state of the information, operational execution challenges, public holidays falling in between the 60-days and the complexity of the assignment, we requested for the assignment to be extended by a month, from end of May 2022 to end of June 2022. The objective of the extension was to allow us to undertake the review procedures that we had set to undertake in the initial 60-days, to the extent possible.

2.13 To undertake investigations aimed at establishing culpability for energy losses, it is necessary to be able to identify the losses arising at each specific stage of the energy transmission and distribution ecosystem to the last possible area of responsibility i.e., a particular customer meter particularly in the case of large power consumers which were the focus of this review. Consequently, one of the key procedures we had proposed to undertake to achieve the objectives of the assignment was an energy balance analysis. This entails analysing the flow of energy from the point of generation, through the transmission network, to the distribution network and eventually to the end consumers. The aim of this procedure was to establish the specific sections of the grid with the most significant losses. This would have informed the focus areas for targeted investigative procedures to establish the cause of the losses, extent of the losses, if there are irregularities and the responsible entities and or persons.

2.14 Ideally, the grid ought to be metered at each of the energy hand-over points to record the quantum of energy passing through. The data from these meters should then be periodically extracted and used for the energy balance analysis. Availability of the metering data in soft and analysable format was therefore a critical aspect of our review procedures. We highlighted this in our proposal to KPLC and in the subsequent discussions with KPLC and the OAG. KPLC confirmed to us the availability of the metering data during the negotiation meeting between KPLC and PwC on 14 December 2021.

2.15 However, after we commenced the review, we observed that the metering data at KPLC was inadequate, had material gaps or was not available in some cases. This we later established was because of widespread metering gaps by way of some of the substations and feeders not being metered, some were metered but not on smart meters thus not automatically transmitting metering data, some were metered but the meter readings were not consistently taken or recorded, human errors in capturing metering data etc.

2.16 This together with other limitations we have highlighted below limited the extent to which we could undertake in-depth data analysis to quantify the losses, identify irregularities and comment on the responsible persons. This necessitated us to apply alternative procedures or manual workarounds which were more time-consuming in nature and not as effective.

2.17 This Report therefore, ought to be considered as a first step towards establishing the cause of the losses, and the interventions that KPLC needs to make to remedy the situation. In the current situation where there are widespread metering gaps and other hindering factors, it is not feasible to comprehensively establish the cause of the losses, time constraints notwithstanding.

2.18 To eventually be at a position where the cause of the losses can be established with certainty, KPLC needs to invest in metering and associated infrastructure, capacity build the team that is tasked with data collection including equipping them with the right tools, collect and analyse the data amongst a raft of other measures that we have set out in detail under Section 3. D of this report.

2.19 With that context, this Report would not be considered suitable for disciplinary procedures as this would require further investigative procedures after the causes of the losses are established.

ii) Other specific information requested and not availed

2.20 The additional listing of information that we requested but was not availed14 below is set out in the table below:

No	Document/Information	Consequence of the information not being availed
1.	Scada feeder load data	This hindered our ability to conduct a complete energy balance analysis aimed at identifying areas of loss.
2.	KPLC and KETRACO apportionment of transmission losses	This hindered us from establishing the loss allocation arrangement between KPLC and KETRACO to comment on what needs to be done to equitably allocate technical losses between KPLC and KETRACO.
3.	Machakos 33KV Feeder ex Katoloni Metering Data	This hindered our ability to conduct an energy balance analysis at the Machakos substation to establish the loss
4.	JKUAT 66 KV Feeder ex Mangu Accurate Metering Data (wrong data shared)	This hindered our ability to conduct an energy balance analysis at the Mangu substation to establish the loss

5.	Maximum Demand on JKUAT 66KV Feeder and all the four Ex JKUAT 11KV Feeders	This hindered our ability to conduct an energy balance analysis at the JKUAT substation to establish the loss
6.	Metering data from Turkwel and Loiyangalani transmission substations	This hindered our ability to conduct a complete energy balance analysis on the Turkwel and Loiyangalani transmission lines
7.	Metering data from Awendo and Ndhiwa transmission substations	This hindered our ability to do a complete energy balance analysis on the South Nyanza transmission grid using metering data. To deal with this limitation, we relied on SCADA data (which is of lower accuracy) for these substations
8.	Transmission losses breakdown per transmission line	This made it difficult to accurately calculate the transmission losses and identify which transmission lines have the most losses that would have informed targeted investigative procedures
9.	C&I Database event logs with user activities.	This hindered us from identifying questionable activities such as alteration of the logs that would have informed further investigative procedures.

iii) Delays in obtaining information and data from KPLC

We note that we experienced delays in getting critical information and data from KPLC for our review[14], for instance:

a) There was a delay in obtaining pre-paid tokens logs data for the period under review due to the size of the data. This hindered us from timely identification of suspicious activities such as concealment or alteration of transactional records that indicate fraudulent activities that would require further investigative procedures.

b) There was delay in obtaining billing data, due to extraction errors that resulted in duplicate records and incomplete data. We could not establish the patterns or trends of power consumption after meter number transfer, customers changing tariffs and upgrades to existing meters.

iv) Operational execution challenges

While the KPLC team that was assisting with the coordination of this engagement was most helpful and cooperative, we experienced several operational challenges that caused delays in the execution of the assignment.

These include unavailability of KPLC technical staff on some days to accompany us to the field due to their other work commitments; KPLC availed to us only nine (9) power loggers against a targeted population of 50 customers which had an impact on the speed and duration of the logging process; we had to relog some customer sites due to technical challenges with the KPLC power loggers.

v) Passage of time

The period under review was July 2018 to March 2022. Due to passage of time, the staff could not accurately recall some events and details. As an example, the KPLC staff that we spoke to could not accurately respond to our query on why some customers do not have smart meters while others do. The smart meters were procured more than 8 years ago and the KPLC staff that we spoke to indicated that they could not recall why meters belonging to some customers had been reallocated to others.

2.21 Despite the above limitations we were able to execute our mandate and to meet the desired objectives of the review. We outline our findings in the following sections.

Findings

3. Findings

A. Overview of the system losses

3.1 The overall objective of the review that we carried out was to assess the possible drivers of the system losses at KPLC, the extent of the losses and to identify opportunities for loss reduction. System losses are comprised of both technical and commercial losses. The focus of our review in line with the Presidential Taskforce directive was on commercial losses, and more specifically in relation to large consumers.

i) Computation of the system losses

3.2 The table below summarises the KPLC power purchases, sales and the resultant loss over a period of eight years according to Request for Proposal ("RfP") from KPLC and the energy data at KPLC that we analysed. A detailed breakdown of the losses is set out in the sections that follow:

Category	2014/15	2015/16	2016/17	2017/18				2018/19	2019/20	2020/21	2021/22*
Units Purchased				10,702	11,491	11,462	12,102				11,578
Units Sold				8,459	8,769	8,773	9,203				8,949
System Losses (GWh)				2,243	2,722	2,689	2,899				2,629
System Losses (%)	17.5%	19.4%	18.9%	21.0%				23.7%	23.5%	24.0%	22.7%
Loss Movement (%)		1.9%	-0.5%	2.0%				2.7%	-0.2%	0.5%	-1.2%
Est Losses (KES M')**	12,464			17,204	20,878	20,625	22,235				20,164
Est Loss Movement (KES M')		2,148	115	2,477				3,674	-253	-1,611	-2,071

Table 29: Summary of KPLC power purchases, sales and the resultant loss over the eight years period 2014 to 2022
**The 2021/22 statistics are as at the end of May 2022*
***Value of the loss based on an average cost of KES 7.6 M per GWh Source: KPLC data*

3.3 Losses are calculated as the net of the units of power purchased and the units of power sold. As shown in the table above, the losses grew rapidly in the years 2015/2016 (1.9%), and again in 2017/2018 (2.0%) to 2018/2019 (2.7%). Thereafter the losses remained relatively constant between 2019/2020 - 2020/2021. In 2021/2022 the losses declined by 1% based on the preliminary KPLC statistics as of May 2022.

3.4 We observed that in the period when the losses were growing rapidly, there were ongoing initiatives and projects that could have contributed to the increase of the system losses. The most notable was the rapid expansion of the grid primarily driven by the rural electrification projects, commissioning of the Lake Turkana Wind Power project ("LTWP"), and commissioning of the Olkaria V generation plant.

3.5 The rapid grid expansion was through increase in the number of customers and the circuit length both of which would have an impact on technical and commercial losses if not suitably managed. Between 2015 – 2021, the number of customers on the grid increased by about 3.3 M, from about 4.8 M to 8.2 M. 98% of these customers were domestic customers mainly in rural areas. Most of the rural areas are typically served by longer Medium Voltage ("MV") and Low Voltage ("LV") feeders that tend to have higher technical losses. Between 2015 - 2021, the circuit length grew by 76,000 KMs from 179,000 KMs to 255,000 KMs. 95,000 KMs of the circuit growth was on the low voltage and medium voltage circuit. Similarly, due to the longer length of the MV and LV network this would have an adverse impact on the system losses.

3.6 Based on the energy purchases data in 2020/2021, LTWP and Olkaria V accounted for 13% and 10%, cumulatively 23% of the total KPLC power purchases. Of the two generators, we sampled LTWP and carried out a further assessment to assess the loss on its respective transmission line in March 2022. We established that the loss on the LTWP line between the point of origin, Loiyangalani, to the Suswa substation to be about 9 GWh which is 5.99% of the power purchased from LTWP for that month. The line is about 430 KMs which could potentially explain the relatively

high loss. Important to note is that the data used to determine the energy received at Suswa was obtained from SCADA which has lower accuracy levels as discussed in subsequent sections.

3.7 We also noted that Kenya Power shifted majority of its ordinary customers, especially in urban centres to prepaid meters in 2019 While this shift was intended to and may have reduced the operational costs associated with meter reading, it elevated the risk of power theft. Since under the pre-paid regime KPLC does not frequently visit customer premises for meter reading, meter bypasses and other malpractices leading to power losses are likely to go undetected. Eng Rosemary Oduor ("Eng Oduor"), the GM Commercial Services and Sales, informed us that KPLC did not employ more meter inspectors as required following the roll out of prepaid meters, hence exacerbating the situation. She attributed this to rejection of proposal to add employ more technical staff by the board.

3.8 Power losses in power utilities are generally classified as either technical losses or commercial losses. Technical losses are losses that occur due to power loss in the infrastructure used for power transmission and distribution. Commercial losses on the other hand are losses because of commercial factors such as faulty meters, errors in meter reading, unmetered consumption, power theft etc.

3.9 Power losses can further be classified into transmission losses and distribution losses. Transmission losses are at the transmission level of the grid (High voltage at 132kV lines and above). On the other hand, distribution losses are losses occurring at the distribution level of the grid (66kV, 33kV, 11kV and Low Voltage ("LV") lines).

3.10 Based on KPLC's analysis, the technical and system losses are as shown in the table below:

Level	Voltage Level	International Benchmark		KPLC (Tetra Tech)*	KPLC (To date)	Movement
		Target Level	Max. Tolerated Level			
Period		1982	1982	2014/2015	2022	
Transmission	220 & 132	1.2%	2.5%	4.5%**	4.15%	-0.4%
Distribution	66	1.9%	3.7%	1.0%	0.71%	-0.3%
	33			1.5%	1.48%	0.0%
	11	2.5%	4.1%	1.2%	2.32%	+1.1%
	MV/LV Sec SS	0.8%	1.7%	1.5%	1.84%	+0.3%
	LV			1.4%	1.93%	+0.5%
	LV Subtotal	0.8%	1.7%	2.9%	3.77%	+0.9%
Distribution Losses		5.2%	9.5%	6.6%	8.28%	+1.7%
Commercial Losses		0.5%	2.0%	6.9%	10.07%	+3.2%
Total Losses		6.9%	14.0%	18.0%	22.50%	+4.5%
				**10 lines responsible for 60% of the 4.5% transmission loss		

Table 30: Technical and System losses
**Tetra Tech – A firm engaged by KPLC in around 2014 – 2015 for a loss reduction assessment program*
**International Benchmark* - Based on a 1982 study by the World Bank Source: KPLC data*

3.11 As shown in the table above, the technical and commercial losses reported by KPLC are above the losses assessed by Tetra Tech in 2015 and the benchmarks in the World Bank report of 1982. This could be an indication that KPLC is suffering system losses that are above the expected levels or the loss calculations have inaccuracies. The power sector constitutes the backbone of the national economy of any country. The world average loss in the electric network system is 8.2% but the as depicted below, there is a huge disparity in nations when grouped by income group and Region

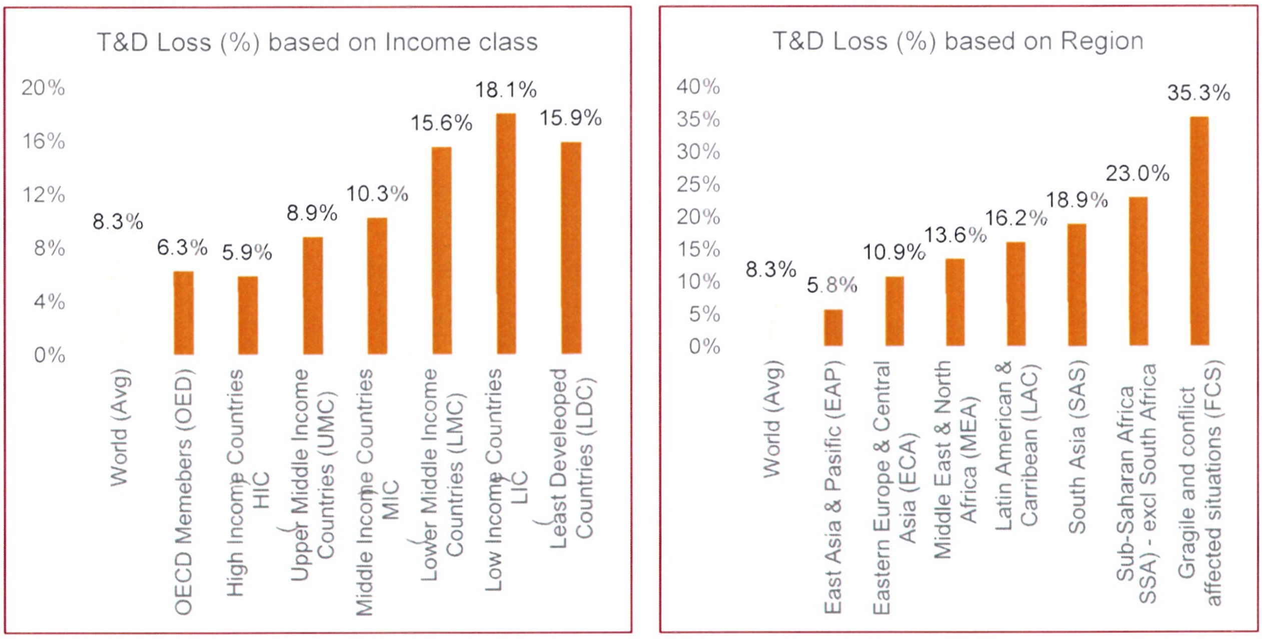

Figure 4: World Bank T&D loss based on region and income class Source : World Bank

3.12 In determining both the technical and commercial losses, KPLC relies on a combination of meters, simulations, and estimates. We made the following observations in how KPLC breaks down the losses which could undermine the reliability of the system losses calculations breakdown:

a. Transmission losses

3.13 Transmission losses are losses incurred during transmission of electricity at high voltages (i.e. 200kV and 132kV) before step down for distribution. The transmission losses calculated on a fully interconnected network will entail the total losses of the transmission line, step-up and step-down transformer losses excluding the generator transformer losses.

i) Some of the transmission substations have no meters, the meters are faulty, or KPLC does not have control and visibility of the meters since they are under KETRACO. In such cases KPLC relies on SCADA data which is considered to have a high margin of error, up to 2%. ii) All losses at the transmission level are assumed to be technical losses. KPLC does not consider the possibility of commercial losses associated with customers connected to the grid at the transmission level.

b. Distribution losses

i) KPLC relies on a combination of simulation and estimates in calculating the technical and commercial losses in the distribution network. These two methodologies are likely to have high margins of error that could skew the loss calculations.

ii) KPLC calculates the technical losses using a simulation software for the MV network and thresholds assessed by a consultant KPLC had engaged in 2015 to conduct a power losses study, Tetra Tech.

iii) Commercial losses are derived as a net of the total system losses (purchases less sales), the losses calculated in the transmission network and the technical losses simulated or estimated in the distribution network. Should there be an underestimation or overestimation of technical losses, this would skew the commercial losses.

3.14 Eventually, a more reliable system of determining the losses would be the use of meters at all levels. In the short-term this may not be possible since as we discuss in the sections that follow, there are significant metering gaps that would need to be first addressed. In the short-term, KPLC could continue with the current system albeit with the inaccuracies but introduce the SCADA data to sense-check the loss calculations.

ii) KPLC Loss Reduction Initiatives

3.15 From our discussions with KPLC Management KPLC, we understand that in the recent past KPLC's loss reduction initiatives were mainly through two main initiatives and teams as listed and discussed below:

a. The Loss Management Unit

3.16 The KPLC Loss Management unit was a unit established in 2015. The main objectives of the unit were the quantification of losses and determination of the where the losses were coming from.

3.17 The unit was domiciled in the Corporate Strategy department, led by Eng Thagichu Kiiru who was the Ag. General Manager Business Strategy. The unit had seven members based at head office.

3.18 Some of the main achievements of the Loss Management Unit include;

i) Recommendation to meter counties i.e., measure the power getting into the particular counties to ensure accountability for county units.
ii) Data gathering and analytics – The unit started use of analytics in the fight against losses at KPLC.
iii) Mapping of grid equipment.

3.19 From our interviews with management, we understand that the main challenge faced by the Loss Management Unit was the lack of representation at the regional and county levels. Their initiatives depended on using operational staff who also had other duties.

3.20 We understand that the Loss Management Unit was disbanded in July 2020 with the members being split and moved to the Network and commercial divisions.

b. The War Room

3.21 The War Room is a committee that KPLC management put in place in August 2020 to fight power losses by KPLC management.

3.22 The mandate of the War Room[1] is to look into opportunities to reduce system losses by 3%, with a focus on Commercial Losses, and improve on debt collection. The War Room reports on a bi-weekly basis to the KPLC Executive Committee.

3.23 The War Room is made of the General Managers of the following divisions;

i) Human resources – Chair
ii) ICT
iii) Business Strategy
iv) Legal and Compliance
v) Regional Coordination

3.24 The War Room also has other five full time members co-opted by their General Managers as the Operational Team. The Operational Team is mainly members from the Commercial and Network Division. The Terms of Reference of the Operational Team is to oversee the implementation of the Committee activities, collect and analyse data, guide the Regional Teams in fighting losses and create an urgency in the fight against power losses.

3.25 According[2] to the War Room current chair, Ms Cecilia Kalungu ("Ms Kalungu"), the GM HR, some of the notable achievements of the War Room are;

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[1] Appendix 26: Loss status & Loss Reduction strategies 2021/22
[2] Appendix 01: Notes from our meeting with Ms Kalungu

i) Reduction of non-vend and zero vend prepaid meters. ii) Reduction of post-paid zero bill meters
iii) Reduction of unmetered connections especially from REREC schemes

iv) Focus on the resolution of smart meter alarms

c. Decrease of the system losses in the year 2022

3.26 We observed that the system losses in year to May 2022 decreased by about 1% as shown in Table 3 above. Based on the KPLC average cost of power, this translates to a saving of almost KES 2B. Our further analysis showed that three KPLC administrative regions contributed to this reduction as shown in the table below. We have also included in the table customers with the most significant consumption increase in that period in those regions i.e. July 2020 – May 2021 vs July 2021 – May 2022.

Region	2020 – 2021 Loss	2021 – 2022 Loss	Change	Large Customer with significant consumption increase
North Eastern	-30.0%	-22.28%	-7.72%	• Supreme Packaging (+305%) • Devki Steel Mills (+42%) • Kevian Kenya Ltd (+40%) • Kifaru Textile Mills Ltd (20%) • Palak Steel Mill Limited (*)
Central Rift	-26.1%	-22.42%	-3.69%	• Rai MDF Limited (+4,595%) • Limited Comply Industries (+331%) • National Cement Company Limited (+128%) • Biashara Master Sawmills Ltd (+90%) • Timsales Ltd (+32%)
Coast	-15.0%	-12.36%	-2.62%	• Mombasa Cement Ltd (+15%) • Jumbo Steel Mills Limited (+131%) • Bamburi Cement Ltd (+6%) • Roofings Kenya Limited (+13,378%) • Tarmal Wire Products (+23%)

Table 31: Large Power customers with significant consumption increase.
**: Had zero consumption in the period 2020 – 2021 Source:*
Our analysis of KPLC Data

3.27 Based on the above observations it would be useful for KPLC to assess in more depth the drivers of the loss reduction in these regions for the learnings going forward. KPLC had not carried out that assessment by the time of our review.

3.28 In doing so KPLC should also interrogate further the large customers with significant power increases in the period to assess the reasons and the extent to which this may have contributed to the loss reduction. This is especially so given that some of the clients are in sectors considered high risk from a power theft perspective. The increases in consumption could however also be driven by increased production for instance. We included some of these customers in our further analysis that we discuss in the subsequent sections below.

d. Conclusion

3.29 As discussed, the system losses at KPLC have been on upward trajectory which could be because of both technical and commercial factors. These include technical losses due to the rapid grid expansion and commercial losses due to reduced vigilance by KPLC, as we have discussed above. At this point it is may not feasible to ascertain with a high degree of accuracy the split of the losses between technical and commercial, and the specific drivers due to limitations such as metering gaps.

3.30 Over the years KPLC has implemented various loss reduction initiatives. The key ones being Building of additional substations to boost voltages and Installation of Feeder metering. These initiatives however do not appear to have achieved the desired outcomes. Based on the persons we spoke to at KPLC and our observations, this is due to lack of a proper structure around the initiatives, lack of follow through and budgetary constraints. These factors would need to be addressed for the current initiative that resulted in this Report to have a better outcome.

B. *Loss assessment in the generation and transmission network*

i) Overview of the losses in the transmission network

3.31 The transmission grid includes the132 kV, 220 kV and above transmission lines. It starts at the point where the power is injected into the grid from generation plants after step-up to the point where the power is stepped down for distribution into the regions.

3.32 The transmission losses encompass losses in the transmission lines, step-up and step-down transformer losses excluding the generator transformer losses. Transmission losses are because of among other factors the profile, load levels and the linear distance of the transmission lines.

3.33 A summary of the calculated transmission losses over the period of our review June 2018 – March 2022[3] is outlined in the table below.

Description					(to Mar)	TOTAL
Energy Purchased into Transmission grid (GWh)					8,895	42,162
		10,870	11,538			
		10,412	11,075			
		18	18			
Energy to Distribution from Transmission (GWh)					8,524	40,394
Exports (UETCL)					11	73
Transmission Losses (GWh)	450		440	445	360	1696
Transmission Losses (%)	4.15%	4.05%		3.86%	4.05%	4.02%
Estimated Cost (Shs'000,000)		3,435	3,471		2,809	13,226

Table 32: Summary of the calculated transmission losses over the period of our review June 2018 – March 2022
Source: Mrep reports 2018 - 2022

3.34 The average transmission loss over this period is 4.02% of the total energy purchased into the transmission grid and the total cost of these losses over the period is estimated at KES 13.2 B based on an approximate average cost per GWh of KES 7.8 M.

[3] Appendix 02: Summary of monthly transmission loss calculations from July 2018 – March 2022 Mrep reports

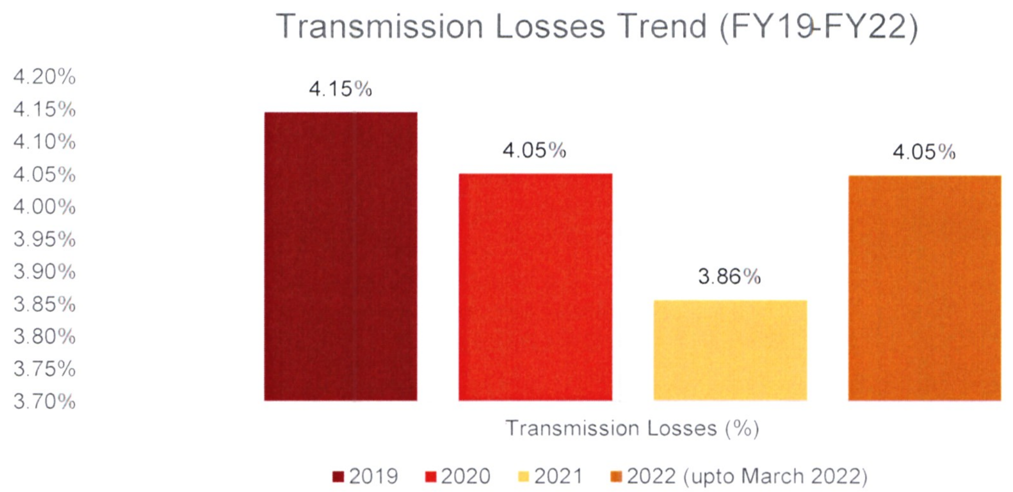

Figure 5: Transmission Losses Trend (FY19-FY22)
Source: Mrep reports

3.35 As shown in the chart above, there seems to be a downward trend in the percentage loss over the period of the 3 complete financial years that we reviewed, FY19-FY21. However, the percentage loss in the current year up to March 2022 is higher than FY21 at 4.05% of the total power purchased into the transmission grid. From our discussions with the network engineers at KPLC, the downward trend in losses could be explained by the fact that the grid is growing and in the last few years, a number of high voltage transmission lines have been added to the grid. With more HV lines, which in turn provide more paths for the power flow, the loading on the lines would reduce leading to a reduction in transmission losses.

3.36 KPLC compiles data collected from generators, transmission lines and bulk supply substations into a monthly report dubbed "*Mrep*" which is used to calculate losses. The transmission loss is calculated as the net of the energy injected into the transmission grid, based on the generation meter readings and the power supplied into the distribution grid from transmission, based on meter readings and or SCADA measurements at the transmission substations and Bulk Supply Points ("BSPs").

3.37 According to the network management team, meters at the generation plants and substations are used in determination of the transmission losses because meters are the most accurate tool to determine the power being injected into the transmission and distribution systems. In areas where there are no meters, the SCADA system is used to determine the estimated energy.

3.38 It therefore follows that accurate determination of transmission losses is dependent on the accuracy of metering at generation, at the transmission substations and at the bulk supply point stations. We noted a number of gaps at all these points that could affect the accuracy of the transmission loss calculations. These are discussed in the sections below.

3.39 In addition, KPLC does not apportion the transmission losses to the specific regions which would be ideal in focussing the loss reduction initiatives.

ii) Possible commercial losses in the transmission network

3.40 At transmission level, KPLC assumes the losses to be technical in nature and therefore does not break the losses into technical and commercial losses. However, we noted that there is a risk of commercial losses at the transmission level emanating from inaccurate metering at the generators and or customers connected to the transmission grid.

3.41 According[4] to Eng Mwangi, the acting General Manager, Network Planning, KPLC does not consider commercial losses at transmission level because of a perceived low risk since their meters are

[4] Appendix 03: Notes from our meeting with Eng Mwangi

sealed by KPLC to prevent tampering. However, as we have discussed in the sections below, we observed metering gaps at the generators and more generally amongst the large power customers which elevates the risk of commercial losses in the transmission network. A recent KPLC investigation and our analysis revealed unusual consumption patterns and possible under-billing on a customer connected to the transmission grid as set out in more detail under C.

3.42 As of May 2022, KPLC had 22 large power customers connected to the transmission grid. In the period 2020 – 2021, the 22 customers consumed about 418 GWh, which translates to 3.5% of the power that KPLC purchased in that period. Some of the 22 customers did not report consumption in the period. The table below summarises the customers with consumption in the period 2021 - 2022:

Customer Name	Meter Number	kWh
Mombasa Cement Ltd	40016110748	154,815,816
Base Titanium Ltd	40016110728	125,179,128
Mabati Rolling Mills Limited	40016110743	62,500,020
National Cement Company Limited	40010112062	22,551,660
Kenya Ports Authority	40013031905	17,863,233
Pan African Paper Mills 2015 Limited	40016110747	14,956,739
Standard Rolling Mills Ltd	40016110752	11,761,608
Abyssinia Iron And Steel Ltd	40016110739	4,986,432
Vipingo Ridge Ltd	40016110729	2,211,666
M/S Mumias Sugar Co	40016110731	2,132,568
Total		**418,958,870**

Table 33: Customer units' consumption(kWh) in the period 2021-2022 Source: KPLC Data

3.43 The customer who did not report consumption in 2021 - 2022 were Devki Steel Mill Ltd A/C No 104832179 (Meter 040016119121), RAI MDF Ltd A/C No. 104830694 (Meters 040013031940 and 040016119140), Rainforest Farmlands Ltd Kenya A/C No. 48727735 (Meter 040016112082), Top Steel (Kenya) Limited A/C No. 78884309 (Meter 040016110739) and a number of generation plants. Devki Steel Mill and RAI MDF Ltd reported consumption in the period July 2021 – May 2022 (5 M kWh and 91 K kWh respectively) while the rest continued reporting zero consumption. Top Steel (Kenya) Limited and Rainforest Farmlands Ltd Kenya had reported consumption prior to July 2020. This could be because of varying factors ranging from them being new customers, the specific meters not being in use if the customer has more than one meter, customers not being in operation, the consumption not being reported, etc. KPLC should investigate this set of customers to understand which of these factors were at play.

3.44 Going forward, KPLC should assess the impact of these customers to the transmission losses and consider apportioning the transmission losses into commercial and technical. This could be achieved by modelling the transmission grid to establish the technical losses and deriving the unexplained or commercial losses as the net of the purchased power, power sent to distribution and the derived technical losses. If there is a difference KPLC should investigate it as it could be because of among other factors, commercial losses.

iii) Metering gaps at the generation plants

3.45 As discussed above, the accurate determination of transmission losses is highly dependent on accurate metering of how much power is received into the transmission grid from generation. Further, the power generation meters are used for payments to the power generators by KPLC.

3.46 Based on discussions with the Chief Engineer in charge of Energy purchases, the energy purchased from the power producers is metered on the output side of generation transformers. i.e., after the power has been stepped up to transmission voltage and hence, KPLC does not incur any transformer losses at the point of generation.

3.47 At generation, two meters are used to measure the amount of energy purchased by KPLC. These are:

i) A main meter which belongs to the power generator but sealed by KPLC.
ii) A check meter which belongs to KPLC. This meter should be used to check the accuracy of the main meter and to act as a backup meter in case the main meter fails.

3.48 Based on KPLC's 2021 energy purchases reports, we noted that only 31% of power plants had functional check meters. The rest had various issues as summarized below:

Check Meters	No of Plants	%
No Check Meter	38	40%
Functional Meters	30	31%
Faulty/Blank	19	20%
Others (No generation /average calculated)	7	7%
Main meter not in operation	2	2%
Total	**96**	**100%**

Table 34: Powerplants with distribution meters
Source: Energy Purchased 2020-June 2021 report

3.49 For the power supply from Ethiopia Electric Utility Company ("EEU"), the main meter was not in operation and the check meter was being used alone to meter the energy purchased. This was also noted at Triumph Power where the check meter is being used without the main meter.

3.50 The metering gaps at the generation plants could potentially lead to overcharging or undercharging by the generators and undermine the accuracy of the energy loss calculations at the transmission level. It is KPLC's responsibility to maintain the check meters through calibration and testing their accuracy so that the check meters play their intended role.

3.51 We discuss the noted deficiencies in more details below:

a. Lack of check meters at some power plants

3.52 As indicated above, 38 power plants of the 96 generating plants did not have check meters installed. All these are off-grid stations which are owned by the Government of Kenya through the Ministry of Energy and the Rural Electrification and Renewable Energy Corporation ("REREC"). We understand that the off-grid plants are run and operated by KPLC on behalf of the government.

3.53 Mr John Ihuthia ("Mr Ihuthia"), Ag General Manager Power Planning and Purchases, explained[5] that lack of check meters at the off-grid plants is due to perceived low risk profile since the plants are operated by KPLC as compared to third party operated plants. However, Mr Ihuthia acknowledged that going forward there is need to have check meters at the off-grid plants for the purposes of corroborating the main meters readings in determining the power that they generate.

3.54 Lack of check meters at the generation stations means that any errors in the main meters may not be caught in a timely manner. This could potentially lead to inaccurate calculation of system loses but also overcharging/ undercharging by power producers. Check meters are crucial not only as a counterchecking mechanism but also as a backup in case of failure of the main meters.

b. Non-functioning check meters

3.55 20% of the generation stations reviewed had check meters which were either off, blank, i.e., they had no readings, or the check meter readings had not been recorded in the reports.

3.56 In our discussions with the energy purchases team, they informed us that the energy purchases report's focus is on the main meters as they are the ones used for determining the energy purchased. They further indicated that while the main meter readings are provided by the power producers on the

[5] Appendix 04: Meeting notes with Eng Ihuthia

first day of the month along with the invoices, the check meter readings which are gathered by KPLC staff are sometimes delayed and received much later.

3.57 The check meter readings have to be provided for invoice verification reports and this is done within 30-45 days of receiving the invoice. We were provided with the Net Electrical Output("NEO") verification report for 2021-2022 where we noted that a reconciliation of the main and check meters was being undertaken and where the variances were due to a typing error, this was corrected. In some cases, further investigation was suggested while in others the corrective measures undertaken, such as meter replacement, are indicated.

3.58 Some of the issues that we noted that affect the functionality of the check meters include:

i) **Challenges in meter clocking** – Some meters freeze the month end readings too early while others freeze late. An example of this is Turkwel power plant where a note in the reports indicated that the check meter was likely not freezing, resulting in very high variances of over 50% in the months of August and September 2020 and over 20% in October and November 2020.

ii) **Blank meters** – we noted instances where the check meters were indicated as blank, meaning that the meter had no reading recorded for that period. Such was the case at Kindaruma in December 2020 and January 2021. At Olkaria II, the check meter for Unit 3 has been reported blank since October 2021 to date.

iii) **Meter off** – there are cases where the check meter was reported to be off. An example of this is Gitaru power plant where the check meter was replaced on 30 April 2021, but the meter is recorded to be off between May and July 2021.

iv) **Faulty meters** – In some cases the check meters were indicated to be faulty, giving erroneous readings which resulted in abnormal variances. In February 2021, there was a slight movement on the meter at Gura power plant despite there being no generation at the plant. A similar issue was raised in one of the Internal Audit reports[6] where it was noted that Olkaria I (Units1,2,3) shut down in June 2020 for 7 months but the meter moved by 4,360,000 kWh in this period.

v) **Triumph Power's main meter failed an accuracy test** in December 2020 and has not been replaced to date. From the reports, it's indicated that the check meter is currently being used for billing. It is not clear why the main meter has not been replaced. Reliance on one meter can result in compromise of meter accuracy due to lack of a counter checking mechanism. It might also lead to non-compliance to PPA agreements if both meters are required to be in place for declaration of the NEO

3.59 According to the PPAs, once the testing and commissioning of the Back-Up Metering Equipment (Check meters) is completed, beneficial ownership of the Back-Up Metering Equipment is transferred to KPLC who shall own and maintain it. It is therefore KPLC's responsibility to ensure that in case of a defect in the check meters, they are repaired, adjusted or replaced accordingly.

c. High variances between the main and check meters

3.60 While most of the generation plants have their overall variance within limits, we noted multiple instances where the variances between the check meter and the main meters were abnormal. According to the PPAs, the metering equipment should provide a measured accuracy of class 0.2% and the acceptable variance limit for these bidirectional meters is +/-0.4%.

3.61 These instances include but are not limited to:

i. Kiambere, the variance in December 2021 was 4.01 %
ii. Gogo, the variance in January 2021 was 33.53%

[6] Appendix 05: Internal Audit Report dated 23 August 2021

iii. Biojoule, with multiple variances above limit including a 25.5% variance in January 2022
iv. Kipevu Diesel Power Plant 1 has consistently had variances that were above the limit since July 2020 with the variance being as high as 38.09% in September 2020. There are comments on the report indicating the need to monitor the check meters however, as at Jan 2022 which is when the check meter readings were last recorded on the report, the variance was at 3%.

3.62 In the instances outlined above, when we enquired from the energy purchases team the cause for the variances, the following explanations[7] were provided:

i. **Kiambere –** Migration of main meters from old to new AMI meters was done between 8 – 10 December 2021 and the check meters have time leads/lags. Further, KPLC is in the process of replacing all the check meters at KenGen plants due to time lags/leads that cannot be corrected due to software unavailability, to conform to 3p4w configuration to match the newly installed main meters and to mop up all the aged meters.

ii. **Gogo -** The variance was caused by a typo error. After correction, there was no variance between the mains and the check.

iii. **Biojoule** - The variance on Net electrical output between the Main and Back-up meter was noted and meter accuracy test was carried out, and the meters accuracy was confirmed to be within the accuracy range as provided on the PPA. However, it is suspected that the variance could be resulting from unsynchronized meter time registers which could lead to the capture and freezing of the closing meter readings at different times. To enable synchronization of the meter clocks; meter programming needs to be examined. Consequently, KPLC is pursuing Biojoule to provide the necessary meter software and meter probe to enable KPLC to access and examine the meter programming and synchronize the meter time registers accordingly.
iv. **Kipevu Diesel Plant 1** - On investigation, it was established that the check meter for Unit 3 was faulty and could not be replaced earlier due to cessation of movement and other constraints within KPLC. However, this was corrected in December 2021. Additionally, the meters also have time lags/leads and there are plans to have them replaced.

3.63 From the reviews conducted, we noted that while NEO reconciliations are done and the variances investigated, there seems to be a significant delay in the resolution of the meter defects that may have been noted.

3.64 Based on our review of the roles and responsibilities of various units, the energy purchases department that is headed by the Chief Engineer, Susan Ombuya ("Ms Ombuya") is ultimately responsible for the metering of power at generation.

3.65 Ms Ombuya explained that whenever a variance is noted, it triggers mechanisms to verify if the main meter is recording the correct values since it is the one used for billing in accordance with the PPAs. These checks include rereading of meters, meter accuracy tests and counterchecking the meter readings with the energy records at the National Control Centre ("NCC").

3.66 According to the energy purchases team, once it is established that the main meter is correct, then further investigations are done on the check meters to establish the cause of the variances and where necessary request for meter replacement and calibration by the Meter Central Lab. Where the main meter is found to be faulty then the check meter may be used for billing. They further indicated that the main meters are regularly tested for calibration and accuracy by KPLC. We were provided with meter testing reports that corroborated this.

3.67 Based on the discussions with the energy purchases team, it seems where the main meter is deemed to be accurate, not much attention is given to the check meters which could potentially explain why some plants have variances over a period of time. While all the grid-connected power

[7] Appendix 06: Email from Chief Engineer, Energy Purchases on high variances between check meter and main meter

plants have check meters installed, there needs to be a push to ensure that all of these check meters are functional and any meter defects should be resolved promptly.

3.68 We also noted that concerns such as unexpected variances between the main meters and check meters, unbilled back-feed and delayed replacement of meters had been raised through the internal audit reports[7] but had not been resolved. An example of this is the Triumph Power's main meter which failed accuracy test in December 2020 and has not been replaced. As of March 2022, the back-up meter was the only being used for establishing the energy purchased. This can compromise meter accuracy because there is no counter check and should the back-up meter have defects, it would hinder the ability to identify that promptly. Follow up needs to be undertaken on the recommendations made on the internal audit reports to ensure that they are implemented within the required timelines.

iv) Metering gaps at the transmission and bulk supply substations

3.69 We noted significant metering deficiencies in the metering of transmission and bulk supply substations which could affect the accuracy and reliability of the data used to calculate the transmission losses, and the energy sent to distribution. These are discussed below and include:

i) Bulk supply substations that are not metered or have faulty meters which cannot be relied upon for the purpose of an energy balance reconciliation.
ii) SCADA has a lower accuracy level and does not cover the entire grid
iii) Gaps in the metering of the transmission lines
iv) Meter readings from KETRACO substations are not available to KPLC.

a. Unmetered Transmission and Bulk Supply Substations

3.70 In calculation of transmission losses, KPLC relies on data from BSPs to determine the amount of energy sent to distribution from transmission network.

3.71 We noted that a number of the BSPs such as Bomet, Awendo, Ndhiwa, Voi, Kitale, Mangu and multiple BSPs in Nairobi region are either not metered, the meters are faulty, or calibration has not been done resulting in erroneous figures. In other instances, the substations belong to KETRACO and the meter readings have not been availed to KPLC as discussed in section B. iv) d below. In these cases, energy statistics recorded in the monthly reports from these substations are either estimates or from SCADA. Data from SCADA is of lower accuracy since it is not defined for this purpose as we discuss in the next section.

3.72 We carried out an energy balance reconciliation using data from the generation meter readings, the monthly reports compiled by the network planning team and the regional metering data[8]. We used the regional data as an alternative to the data from the network team's monthly reports to determine the total energy sent to distribution from transmission.

3.73 The table below shows the transmission losses for the period June 2020- March 2022 compared with the loss calculated using the National Control Center ("NCC") monthly reports data.

	2021		2022 (up to Mar 2022)	
	Regional Data	**Mrep Data**	Regional Data	Mrep Data
Total Generation (GWh)	12,101	12,101	9,457	9,457
Exports (UETCL)	18	18	11	11
Generation into Transmission network (GWh)	11,483	11,538	8,903	8,895
Distribution from Transmission (GWh)	11,089	11,075	8,508	8,524
Transmission Loss (GWh)	**396**	**445**	**385**	**360**
% Loss	**3.45%**	**3.86%**	**4.32%**	**4.05%**

[8] Appendix 07: Regional energy report from July 2020 – March 2022

Estimated Cost (Shs'000,000)	**3,091**	**3,473**	**3,000**	**2,809**

Table 35: Transmission losses for the period June 2020- March 2022 compared with the loss calculated using the NCC monthly reports data
Source: Mrep reports, Regional Energy Input report

3.74 The regional data contains meter readings from distribution feeder meters where there are no functional meters at the transmission substations. Similarly, some of the estimates used in Mrep reports are drawn from meters at distribution level.

3.75 Therefore, in both calculations, because data from distribution substations and feeders has been used to estimate energy from transmission to distribution, it is possible that that the transmission loss may be lower than the calculated value using regional data. Part of these losses may be distribution losses, which include both technical and commercial losses.

3.76 The noted difference between the two calculations can be attributed to the difference in the metering information used by the network teams and regional teams. The network planning team bases their calculation on metering information at the various bulk supply points, transformer meter readings and in cases where meter readings are not available, SCADA data is used to fill those gaps. The regional data is obtained from multiple sources including border meters, feeder meters and regional data from the NCC.

3.77 It is crucial that functional meters are installed and maintained in all the BSPs for accuracy of the transmission losses calculations.

b. SCADA coverage limitation and lower accuracy of the data

3.78 SCADA covers a majority of the distribution and transmission stations, where it gathers data using remote terminal units ("RTUs"). This data is sent to the network team for analysis. During our discussion[9] with the network management team, we were informed that while in some cases the data from SCADA is a perfect match with what is on the meters, in others the SCADA readings are different from what is on the meters.

3.79 The SCADA unit is under the Service Delivery and Telecommunications Department headed by the General Manager ICT division. According to Eng Metrine Jelagat ("Eng Jelagat"), the decision on which stations are to be integrated to the SCADA system comes from the Network Management Division which is headed by Ag GM, Eng Mwangi. She further advised that all new stations being integrated to the grid are required to be implemented with SCADA by design. She however noted that some new substations have been integrated without SCADA because the SCADA team was not involved during implementation as required.

3.80 The discrepancies between SCADA and meter readings are attributed to the different means of acquisition and the mode of transmission of the data which could be susceptible to errors. According to the SCADA engineers who we spoke to, the accuracy required for SCADA is lower than that of the commercial meters because it is designed for technical and not for commercial purposes.

3.81 Additionally, not all generation and transmission substations are covered by SCADA. Of the 40 generation plants on the interconnected grid, 12 are not on the SCADA system. We were informed by the SCADA team that of the 316 substations that KPLC operates, 232 substations are on SCADA, 23 are currently being connected while 61 substations are not on SCADA.

3.82 During our review, we requested for SCADA data for the LTWP generation plant at Loiyangalani which feeds energy to the Suswa substation. In analysing the data from SCADA, we noted that the values provided were erroneous with the total generation given as 19,197 GWh which is way above the 150 GWh recorded by the energy purchases meters. Notably the data provided had the same amount of energy produced from each transformer which is unlikely. See table below:

	SCADA March 2022

[9] Appendix 08: Meeting notes of meeting with the SCADA team

LOIY TX1-IMP	6,442,440
LOIY TX1-EXP	30,814
LOIY TX2-IMP	6,442,440
LOIY TX2-EXP	30,318
LOIY TX3-IMP	6,442,440
LOIY TX3-EXP	68,200
Total at Loiyangalani (MWh)	19,197,988
GWh	**19,197.99**
Energy purchased from LTWP (Gwh)	**150.23**
Variance	19,047.76

Table 36: SCADA data for the LTWP generation plant at Loiyangalani Source: KPLC Data

3.83 We discussed this observation with the SCADA team, and they indicated that SCADA data from Loiyangalani was not updating in the system which could be the reason for the abnormal figures. Eng Jelagat, one of the SCADA engineers, further indicated that the equipment feeding data to SCADA at Loiyangalani had been off for over a year but efforts to have these reinstated have not been successful.

3.84 This goes to show that SCADA data is prone to errors and has a lower degree of accuracy. However, where abnormal discrepancies exist on the SCADA data, KPLC should investigate and rectify.

c. Gaps in the metering of the transmission lines

3.85 From our discussions with the network management team[10], transmission lines are metered at points of origin to the next point of entry. However, from our review of the Mrep reports, we noted that some of the transmission line meters are faulty and have errors, the meter readings are not available, or the meters are off. There are also cases where the metering of the transmission lines is not end to end making it difficult to assess the energy flowing through a transmission line accurately.

3.86 For instance, we observed that the Lessos - Lanet line which has consumers connected to the transmission grid is not metered end to end with a lack of metering on the transmission lines at Soilo and Makutano substations. It is thus difficult to reconcile the energy flowing through this line and even to determine how much energy was sent to the customers from the grid. Reliance is placed on the customer meters alone and this would make it difficult to identify commercial losses if there were any.

3.87 Ms Mary Njau ("Ms Njau"), an engineer in the NCC team indicated that they had attempted to carry out calculations of transmission losses by line, but this was not successful due to the metering gaps. In addition to lack of meters at key points, she noted that some meters were not well calibrated resulting to abnormal readings, sometimes the meter readings are not taken in good time or the readings are not shared with the NCC team. Furthermore, she noted that the line-by-line analysis did not have any users within KPLC and hence was not prioritized. Due to the above limitations KPLC does not break down transmission losses by line.

3.88 When we spoke to the Ag GM Networks, Eng Mwangi, he explained that the transmission line meters are not well calibrated or maintained and hence they cannot be relied upon. He further stated that investing in the installation and maintenance of transmission line meters is very expensive. He noted that the focus is on using lower cost methods of determining losses and loss reduction such as the use of load levels and they have confidence in the accuracy of these procedures. However, as we have discussed subsequently, due to the various metering gaps in the system the methods being

[10] Appendix 09: Meeting notes of meeting with the network team

used currently to determine transmission losses are flawed and may not be giving an accurate indication of the loss level.

3.89 In our meeting[11] with the General Manager Network Management[13], Eng Charles Mwaura ("Eng Mwaura"), he mentioned that the energy Studies team undertakes the calculation of transmission losses on a per line basis. We however note that KPLC did not provide such a breakdown upon request.

3.90 This is a key area that requires attention as loss calculation by line would give a more accurate picture of the total transmission losses in the grid and the contribution of individual lines to the transmission losses. This will enable the loss reduction initiatives to be more targeted on the lines with the most impact on the grid.

d. Meter readings from KETRACO substations are not available to KPLC

3.91 We observed that meter readings from some of the major bulk supply point substations were not available to KPLC's NCC team which carries out the transmission loss calculations. This is because these substations belong to KETRACO and hence do not have KPLC meters.

3.92 An example of this is the Loiyangalani and the Suswa substations where we were not able to find the meter readings on record. While this line does not have consumers connected to it and its loss would be largely a technical loss, being able to accurately measure the energy losses on this line would be beneficial to KPLC. SCADA data is used where metering information is not available but as discussed previously, the accuracy of this data is not satisfactory.

3.93 At Awendo substation, the Kegati and Ndhiwa 132 KV lines were indicated to have erroneous readings from KETRACO meters and there are no KPLC meters currently installed.

3.94 The unavailability of metering data at key points undermines the reliability of data which is used by KPLC to determine the system losses and possibly in risk sharing between KETRACO and KPLC. KPLC should consider enhancing the information exchange mechanisms with KETRACO, agreeing, and enforcing metering standards for the KETRACO meters. We requested for the operational agreements between KETRACO and KPLC if any, but these were not provided to us[12].

v) Possible miscalculation of transmission losses

3.95 As per the network management team, transmission losses are calculated as below:

Transmission Losses = Energy purchased into the transmission grid *less* Energy sent to distribution from transmission grid *less* Exports

3.96 The energy purchased into the grid is obtained by taking the total energy from the generation plants, excluding off grid generation and embedded generation which is fed directly into the distribution grid. Energy sent to distribution from the transmission grid is obtained from metering data at the bulk supply stations. These include the various transmission stations and consumer meters in cases where the consumers are connected to the transmission grid.

3.97 The transmission losses calculated on a fully interconnected network will thus include the total losses of the transmission lines, step-up and step-down transformer losses excluding the generator transformer losses which are borne by the power producers and do not form part of the transmission losses.

3.98 We observed some gaps with this approach that could distort the transmission loss calculations. The approach that KPLC uses is that the total energy purchased from the grid-connected generation plants is the total energy into the transmission network. However, we noted that at Turkwel, the total

[11] Appendix 10: Notes from our meeting with Eng Mwaura
[13] On suspension at time of review.
[12] Appendix 25: List of documents not provided

energy purchased includes energy metered on an 11kv feeder ("Camp feeder") which supplies KPLC's local customers at Turkwel. When the transmission losses calculation is done, the total energy purchased into the transmission grid at Turkwel includes this energy fed into the camp feeder. This can lead to inaccuracy in the loss calculation given that it includes energy fed to local distribution which would include distribution losses.

3.99 A more accurate representation of the energy purchased into the transmission grid would be metering data from the transmission lines at the point of origin into the transmission grid.

3.100 Potentially, there could be misreporting of distribution and commercial losses as transmission losses because the BSPs are not adequately metered and sometimes the values used are approximations, derived from feeder meters fed by the BSPs or derived from SCADA which as we have discussed in the preceding sections, are not very reliable.

3.101 Metering errors and gaps at the transmission level and at the BSPs, which we have discussed above are likely to cause an overstatement of the transmission losses which in turn would result in an understatement of likely commercial losses at distribution level since these are derived. It is therefore of paramount importance for KPLC to ensure complete metering of critical points such as the BSPs, and the transmission substations to be able to obtain an accurate representation of the losses in the transmission network.

3.102 We discus below the discrepancies that we observed.

a. Discrepancies in the calculation of transmission losses

3.103 We sampled and reviewed the Turkwel - Lessos - South Nyanza and the Loiyangalani - Suswa transmission lines for analysis of the transmission lines losses.

3.104 We were not able to obtain the metering data for the Loiyangalani – Suswa transmission lines since Loiyangalani and Suswa substations are owned by KETRACO. As previously noted, KPLC does not have visibility of meter readings at KETRACO substations. We were provided with the SCADA data for the transmission line and used this and the energy purchased report to calculate the transmission loss.

Loiyangalani - Suswa 220 KV Line	Mar-22
LTWP Generation (Energy Purchased report)	150,232,800
Import at Suswa (SCADA data)	141,232,032
Loss (KWh)	**9,000,768**
Loss (%)	**5.99%**

Table 37: Transmission Lines Losses
** SCADA data and energy purchased report Source: PwC analysis of KPLC data*

3.105 We established that for the month of March 2022, the loss on the Loiyangalani- Suswa 220 KV line is about 9 GWh which is 5.99% of the power purchased from LTWP for that month. Although the line is about 430 KMs, this loss is relatively high, and this might partially be explained by the fact that SCADA data has lower accuracy than metering data which would be more reliable.

3.106 We similarly calculated the transmission line losses for the Turkwel - Lessos line for the month of February and March 2022

Turkwel - Lessos 220KV	Feb -22		Mar-22	
	PwC	KPLC	PwC	KPLC
Generation	47,111,100	47,111,100	53,046,700	53,046,700
Turkwel Local Consumption (11 KV)	(44,100)		(50,700)	
Export to Kainuk (220KV)	(163,920)	(163,920)	(190,334)	(190,334)
Export from Turkwel to Lessos	(46,116,500)		(51,963,700)	
Turkwel - Lessos 220KV	**Feb -22**		**Mar-22**	
	PwC	**KPLC**	**PwC**	**KPLC**
Turkwel Loss (KWh)	**786,580**		**841,966**	

Turkwel Loss (%)	**1.67%**		**1.59%**	
Add Cedate generation	7,621,986	7,621,986	9,883,400	9,883,400
Less Cedate Consumption	(28,260)		(27,574)	
Add Selenkei generation	7,569,207	7,569,207	8,410,871	8,410,871
Less Selenkei Consumption	(27,800)		(23,975)	
Total Energy from Turkwel to Lessos	61,251,633	62,302,293	70,206,422	71,340,971
Energy received at Lessos from Turkwel	(59,403,900)	(59,403,900)	(68,100,100)	(68,100,100)
Transmission Line Losses	**1,847,733**	**2,734,473**	**2,106,322**	**3,050,537**
TL Losses % of Total generation	**2.97%**	**4.39%**	**2.95%**	**4.28%**
Total System Loss (Loss 1 +TL Loss) (KWh)	**2,634,313**	**2,734,473**	**2,948,288**	**3,050,537**
% of Generation	**4.23%**	**4.39%**	**4.13%**	**4.28%**

*Table 38: Transmission line losses for the Turkwel - Lessos line for the month of February and March 2022 ** PwC Analysis of Data from Mrep reports 02-22,03-22 Source: PwC analysis*

3.107 In our loss calculation for the Turkwel - Lessos line we used the meter reading at the start of the transmission line at the Turkwel substation to determine the power injected into the line and the transmission line meter reading at Lessos to determine the power received at Lessos. We also factored in the power injected at Cedate and Selenkei generation plants as well as the back-feed energy.

3.108 For comparison purposes, we also arrived at a deduced loss based on the formula used by KPLC to calculate transmission losses. KPLC's calculation determines transmission losses by taking the total energy purchased into the transmission network less energy sent to distribution at the bulk supply stations. This calculation does not factor in back-feed energy at the generation plants.

3.109 Based on these two approaches, our loss calculation on the Turkwel – Lessos line for February 2022 resulted to a loss of 4.23% of generation which is marginally lower than the deduced loss of 4.39% of generation as per KPLC's approach. We established that the KPLC loss calculation is higher because it does not exclude energy purchased from the Turkwel generation plant and distributed to the local area at 11kv and back feed along the transmission lines i.e. at the Cedate and Selenkei generation plants.

3.110 We also noted that there appears to be a system loss of 1.7% of the energy purchased at Turkwel before the energy is injected into the Turkwel – Lessos transmission line. Therefore, using the energy purchased rather than the energy metered on the transmission line would result in a higher calculated loss although part of this loss might be commercial, or as a result of metering errors.

3.111 For South Nyanza, we calculated a transmission loss of 7% on the Kegati – Awendo - Ndhiwa transmission line in February 2022 as shown in the table below.

South Nyanza Transmission Losses	KWh
Receipts at Kegati (Kegati Ex Chemosit 132 KV Line)	22,076,000
Energy into Distribution at Kegati	-12,202,740
Energy into Distribution at Awendo	-3,695,078
Energy into Distribution at Ndhiwa	-4,377,730
Total Receipts into South Nyanza	**25,469,611**
Transmission Loss (Kegati- Ndhiwa)	**1,800,452**
%(Transmission Loss/Total Receipts)	**7.07%**

Table 39: South Nyanza Transmission Losses Analysis on Kegati-Awendo-Ndhiwa Transmission Line Source: PwC analysis of KPLC data.

3.112 We also calculated a total system loss of 40% in the South Nyanza region which is discussed in the section 3. C. iii below. On further analysis, we noted that 13.8% of the total system losses occur at

Kegati substation. According to the South Nyanza[13] regional manager and his team, this loss is likely due to metering errors at the feeders exiting Kegati substation and this is currently being investigated.

3.113 Given this assessment, we would recommend that KPLC ensures that the various meters at both the generation points and at the bulk supply stations are put in place and properly serviced, and that reconciliations that go up to individual feeder levels are done. Where the stations are owned by KETRACO, KPLC should obtain the metering data from KETRACO and ensure the KETRACO meters are serviced frequently. Monitoring of the entire transmission network using SCADA should also be considered to ensure that abnormal losses are detected and actioned in a timely manner.

b. Transmission Losses above international benchmarks

3.114 We observed that the transmission losses at KPLC range between 3% - 5% and average at 4.5%. which translates to a 95.5% transmission efficiency. This transmission loss level is above the international benchmarks which typically suggest the target level at 1.2% and the maximum tolerated levels as 2.5%.

3.115 For reference, we looked at the transmission loss level of power utilities in India. We observed that for a transmission utility viz. TS-Transco, which supplies to a consumer base similar to KPLC, has a transmission loss level of 2.47% in FY 2021-22, while the monthly transmission losses range from 2.17% to 2.67% in the financial year. Similarly, the transmission losses related to inter stare transmission as recorded by India's National Load Dispatch Center has reported an average weekly transmission loss of 3.42%, with a loss reaching to the minimum of 2.80% during the second week of September 2021.

3.116 According to the 2015 Tetratech report[16], preliminary calculations by KPLC based on a modelling of the transmission network suggested the technical energy losses would be around 2.4%. Based on this calculation, it suggests that commercial losses and other forms of unexpected losses could make up about 2% of the transmission losses. It is, however, difficult to verify this as measuring the commercial losses at transmission level is challenging due to inadequate metering of the transmission lines.

3.117 Commercial losses at the transmission level would result largely from gaps in the metering at the generation points and customers connected to the transmission network. We have discussed the gaps we observed at the generations points in the preceding sections. As of May 2022, KPLC had 22 large power customers connected to the transmission grid. In the period 2020 – 2021, the 22 customers consumed about 418 GWh, which translates to 3.5% of the power that KPLC purchased in that period.

vi) Conclusion

3.118 KPLC should assess the impact of customers connected to the grid at transmission level and establish whether some of the losses that are considered as technical losses could be commercial losses and reclassify them accordingly. Customers who did not report consumption in the period 2021-2022 should also be investigated to establish why this was the case.

3.119 A breakdown of transmission losses by transmission line should be undertaken to give KPLC an opportunity to identify any transmission lines with higher-than-expected losses that would inform suitable loss reduction measures as well as to identify transmission lines with potential commercial losses.

3.120 We observed metering gaps at various points from the generation substations to the bulk supply points. Dysfunctional meters could lead to overcharges or undercharges at the energy purchase points which would go undetected, these should be remediated as a matter of priority. At the bulk supply points, KPLC should work with KETRACO to ensure that all the meters are functioning

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[13] Appendix 11: Meeting notes for meeting with South Nyanza regional team [16]
Appendix 12: Extract of 2015 Tetra Tech report.

appropriately to ensure accurate measurement of energy and accurate determination of losses. We have outlined further recommendations in *section 4 and 5* of this report.

C. *Loss assessment in the distribution network*

i) Overview of the losses in the distribution network

3.121 As per KPLC records, the technical losses in the distribution losses in the period of review were as follows:

	% Loss between periods			
Month	**Nov 2019**	**Jun 2021**	**Nov 2021**	**Mar 2022**
66 kV	0.7%	0.6%	0.7%	0.7%
33 kV	1.3%	1.4%	1.5%	1.5%
11 kV	2.3%	2.3%	2.9%	2.9%
MV\LV Secondary Substations*	1.5%	1.8%	1.5%	1.5%
LV*	1.4%	1.9%	1.4%	1.4%
Total Technical Loss	**7.2%**	**8.1%**	**7.9%**	**7.9%**
Derived Commercial Losses	11.9%	11.12%	10.75%	10.52%
Total Distribution Losses	**19.19%**	**19.19%**	**18.69%**	**18.46%**

Table 40: Distribution technical losses in the period of review
Source: KPLC calculations
**The above figures are between the periods listed hence don't correspond to annual figures*

3.122 As shown in Table 40 above, KPLC simulations and calculations show that distribution losses have reduced over time. As described in the section 3 A i) b above, we note that the above distribution losses are not measured directly, but rather apportioned from the total system losses using simulations and calculations. The exact methodology of determining the distribution losses is discussed under C ii) b below.

3.123 As such, the main drivers of reported distribution losses at KPLC are the general trend of total system losses, the system peak loads during the period and the addition/reduction of active feeders and distribution equipment to the grid.

3.124 As shown in the table, the KPLC calculations show that distribution losses have reduced from a peak of 19.9% in June 2021 to 18.46% in March 2022. From our discussion with management, this trend can be attributed to the various efforts by KPLC to fight the overall system losses.

3.125 KPLC calculations also showed that Technical losses, the part of distribution losses attributable to losses due to grid operations, to have peaked in June 2021 at 8.1% and dropped to 7.9% to March 2021. The relatively small change between June 2021 and March 2022 (-0.2%) is due to the fact that the load profile and the feeders and equipment in the grid did not change very much in the nine months.

3.126 The commercial losses however seem to be in a downward trend, dropping from 11.9% in November 2019 to 10.52% in March 2022. This is because majority of the reductions in system losses in the period are likely attributable to a reduction in commercial losses due to the fact that technical losses are driven by grid design which does not vary very much over time.

3.127 We further noted from our discussions with KPLC management that over the period reported in the table above, KPLC has embarked on various initiatives to reduce commercial losses as discussed in section 3 A ii) above.

ii) Gaps and opportunities for improvement in the distribution loss calculations

a. Energy balance and reconciliation at the distribution feeders and transformers level.

3.128 For KPLC to address its power losses, it is necessary for the company to be able to accurately determine which sections and regions of the grid are contributing to the most power losses. This will allow KPLC to undertake a cost benefit analysis of the available power reduction options and to adopt the most optimal initiatives.

3.129 Energy balance or energy accounting refers to accounting of all energy inflows at various voltage levels and energy consumption by the end consumers. It helps in verification, monitoring and analysis of energy usage, preparation of technical reports for improving energy efficiency of the network and can also support to develop an action plan to optimise energy consumption. Typical prerequisites for periodic (annual/quarterly/monthly) energy balance include:

i. Identification and mapping of consumers and all electrical network assets.
ii. Installation of functional communicable meters for consumers, transformers, feeders. iii. IT enabled system to create energy accounting reports without manual interference.
iv. Creation of centralized energy accounting and audit cell comprising of nodal officers, energy manager, IT manager and financial manager.
v. Verification and validation of the system metering data provided through random field visit

3.130 From our discussions with KPLC management, we understand that KPLC before 2015 did not focus on apportioning power losses across it network. In late 2015, the then CEO and MD, Dr. Ben Chumo, formed a loss management unit was to specifically address the issue of power losses.

3.131 As discussed in section 3 A ii) a above, one of the initiatives of the Loss Management Unit was energy accounting (energy balance) across KPLC power network to identify sections of the transmission grid where much of the power losses were occurring. To achieve this, the Loss management unit recommended feeder and transformer metering.

3.132 Despite some progress made in this regard, currently, KPLC is only able to do energy balance up to regional level. Energy reconciliation at county level, feeder level and transformer level has not been done and may not be possible under the current circumstances. This is due to metering gaps as discussed in various sections of this report as well as challenges in mapping end consumers to feeders, transformers and KPLC's administrative regions. Some of the factors that have contributed to the mis-mapping of customers include ease of relocating pre-paid meters by the customers, human errors during data entry and poor data management practices particularly during data migrations.

3.133 We also noted that KPLC was only able to provide reliable and consistent feeder meter readings for only a few feeders with smart meters. The data for meter readings for non-smart feeder meters was neither compiled nor structured in easy to analyse format. This further complicates energy accounting efforts.

3.134 Given that to undertake proper energy accounting across the grid is critical for KPLC's efforts to reduce losses, KPLC needs to;

i. Fast track the feeder and transformer smart metering initiatives.
ii. In the interim, structure the collection and collation of non-smart meter readings through a central platform where the data can be stored and retrieved for analysis.
iii. Fastrack the FDB/GIS Clean Up Project that the National Youth service ("NYS") is implementing.

iv. Automation of repeat tasks in energy balance calculations. Auto-updating dashboards which automatically pick data from centralised sources could be a plausible option.
v. Capacity building in data analytics through acquisition of requisite tools and having a designated competent team.
vi. Development and implementation of an organisation-wide data governance and management strategy.

b. Use of simulations and estimates to assess technical losses.

3.135 As discussed earlier, power losses in power utilities are generally classified as either technical losses or commercial losses. Technical losses are losses that occur due to power loss in the infrastructure used for power transmission and distribution. Commercial losses on the other hand are losses because of commercial factors such as faulty meters, errors in meter reading, unmetered consumption, power theft etc.

3.136 Power losses can further be classified into transmission losses and distribution losses. Transmission losses are at the transmission level of the grid (High voltage 132kV lines and above). On the other hand, distribution losses are losses occurring at the distribution level of the grid (66kV, 33kV, 11kV and associated LV lines.

3.137 KPLC calculates transmission losses mainly using meters and using the SCADA system where the meters or meter readings are not available. Meters are more reliable. In contrast however, KPLC relies on software simulations and estimates to determine technical losses in the distribution network. KPLC derives commercial losses as the residual losses upon subtracting transmission and distribution technical losses from the overall system losses.

3.138 The above approach implies that any errors in the transmission and technical loss calculations will impact the accuracy of the derived commercial losses. We understand that KPLC uses simulations in the determination of distribution losses because of:

i. Lack of adequate metering on all the feeders. ii. Simulation can provide an estimate of technical losses which when deducted from the Distribution losses can yield the commercial losses which cannot be measured directly.
iii. With the feeder parameters in the FDB the modelling and calculation is faster than attempting to do everything manually.

3.139 The KPLC network Planning teams simulates distribution technical losses using the approach summarised in the table below:

No.	Level	Simulation process
1	66kV	Use of the PSS SINCASS Simulation tool
2	33kV	Use of the PSS SINCASS Simulation tool
3	11 KV	Use of Microsoft Excel based models for simulation
4	LV network	Use of adjusted estimates from a 2015 power losses report by Tetra Tech

Table 41: Simulation of Technical losses Source: Discussions with KPLC

3.140 We note that for 66kV, 33kV and 11kV, the models are based on basic power loss principles i.e., power loss is dependent on the conductor current, conductor size, conductor length, conductor characteristics and the power profile.

3.141 From our review of the simulation approach that KPLC employs, we noted that the simulations may not be entirely accurate because:

i. The simulation is only done twice a year and assumes a normal topology of the network. i.e., the connectivity among power system components such as generators, power transformers, transmission lines, loads, etc remains constant in the six months. This in effect implies that the percentage of technical losses remains constant and only commercial losses vary on a month-to-month basis within the period.

ii. We found the above assumption erroneous because simulation does not take care of rapid operational changes that happen month by month.

iii. The simulations ignore many small branches located along the main feeder lines in determining feeder length where the loads are not very significant. According to KPLC, this is done to simplify the simulation as it would be otherwise be unjustifiably time-consuming.

iv. For technical loss simulation, the lengths and conductor sizes are obtained from the FDB (Facilities Database). If the information in the FDB is not correct, then the losses simulation will also be incorrect. We for instance noted that a total of 37 33kV and 11kV feeders are indicated as having zero length in FDB. It is therefore important that the FDB must be kept up to date with correct information about conductors and distances.

3.142 To calculate Feeder losses, it is an acceptable practice to use some empirical formulas. The simulation for 33KV and 66 KV uses the same empirical formula

Peak Loss in a Feeder = I_{max}^2 x rL .... Eqn. 1

Where I_{max} is the peak current in a particular feeder r –

resistance per unit meter or Km depending on the units

L- Consolidated Feeder Length in Meters or Kilometres

Feeder Losses= $LLF \times peak\ loss \times hours\ in\ a\ year$/month ....Eqn. 2

Where LLF is Load Loss Factor

LF = Feeder Load Factor

For urban Feeders the loss formula is represented as

$LLF = \alpha\ LF + \beta\ LF^{\wedge 2}$ ....Eqn. 3

For urban and commercial network: α = 0.3 and β = 0.7 and therefore

LLF_{urban} = 0.3 LF + 0.7LF^2 ....Eqn. 4

For rural and domestic network: α = 0.2 and β = 0.8 and therefore

LLF_{rural} = 0.2LF + 0.8LF^2 Eqn. 5

3.143 From the above formulas, to calculate feeder loss, one needs Imax which is the peak current of a feeder within a certain period typically in a particular month. This can be obtained from a meter at the beginning of the feeder that is able to freeze the maximum load in MW and Power factor from which peak current can be calculated.

3.144 From energy measurement in a month from the meter one can determine the average load in the feeder. The load factor is the ratio of the average load to the peak load. Using the feeder load factor the particular feeder's loss factor can then be derived from the empirical formulas cited above. However, due to challenges with feeder metering, KPLC is not able to determine the feeder loss factors for feeders.

3.145 As a workaround, KPLC simulations use the national systems load factor obtained from the previous year's annual statements to obtain a Loss Load Factor ("LLF"). The LLF is a ratio of the average loss in the feeder to the peak loss. KPLC then assumes that this LLF is applicable to all feeders in the network in the current year. Average feeder losses are then deduced from this LLF.

3.146 The above workaround affects the accuracy of the simulations. This is because feeder load factors vary monthly hence the assumption that previous year's one LLF applies to all current feeders, differentiated only by whether they are rural or urban feeders, is not an accurate representation of the reality. Each feeder has a different LLF which is dependent on its load factor and the load factor varies from month to month.

3.147 KPLC applies the different LLF in the simulation depending on whether a feeder serves a rural area or an urban area. Our calculation of feeder losses based on individual feeder parameters and their monthly load factor yielded different losses compared to the simulated losses. Our calculated losses were lower by 20% compared to the simulated losses. The feeder we analysed, the Machakos Feeder ex Konza, had a lower load factor of 0.6 compared to the global systems load factor of 0.69 which is used for all feeders. The LLF for the simulation was 0.54 while that for the feeder was 0.432 in March 2022. We attributed the variance to the fact that the simulation does not consider individual load parameters monthly.

3.148 The loss in a particular feeder is a function of the peak loss and the LLF. When the network planning team updates the simulation after 6 months, they only change the peak loss but do not change the LLF which affects the average load of the feeder. LLF remains constant for a whole year because KPLC uses the systems load factor from the previous financial year to calculate it and ignores the average load in the feeder. If there are any feeders added to the network since the previous simulation or changes in the length of feeders, then they would be incorporated into the model at this stage and included in the simulation. Without a 100 % feeder metering then even peak loads in some feeders are estimates.

3.149 Given the complexity of the KPLC network, lack of metering data and other challenges, we note that despite the simulation exercise being tedious and inaccurate, the simulation of losses appears to be the most feasible that KPLC can do in the circumstances.

3.150 With the use of average LLFs and average feeder loses, KPLC misses out on the loss assessment objective of identifying high loss feeders and using this information to take targeted loss reduction measures such as replacement, reducing line length, increasing HT/LT ratio etc.

3.151 We however note that KPLC can make a significant improvement to the accuracy of the simulation by incorporating accurate peak loads in the simulations. This can be achieved by installing smart meters in all feeders and ensuring that they are accurately calibrated. This will ensure that the peak load is accurately recorded in all the feeders since it is a significant parameter in technical loss determination. Current smart meter coverage is at 52%.

3.152 Further, once the proper mapping of customers to feeders is completed the simulation process can be automated so that it picks monthly peak loads from the relevant systems. The feeder Load factor can also be calculated and used in the simulation instead of the previous year's global system load factor. The commercial loss per feeder can then be calculated as net of the power injected in the feeder, customer bills and the derived technical loss.

c. Metering gaps and deficiencies

3.153 Throughout the distribution network we observed metering gaps that impair KPLC's ability to monitor and effectively address system losses. These gaps contribute to the current situation where KPLC does not undertake a comprehensive energy balance calculation in the distribution network to flag out the parts of the distribution network with the most losses.

3.154 We were similarly not in a position to undertake the energy balance calculation since the requisite metering information was lacking. We discuss some of the metering gaps that we observed below:

c-1) Unmetered counties, substations, feeders, transformers and customers

1. County Border metering:

3.155 Border metering of the various administrative units at KPLC is crucial for energy accounting. It is imperative that KPLC is able to, with a certain degree of accuracy determine the energy received and billed in the various administrative units.

3.156 Thus, effective county border metering will assist KPLC in holding the staff in the various counties accountable for the power that is fed into the counties. It will also help KPLC in accurately determining the counties with the highest losses, allowing KPLC to come up with targeted loss reduction measures for those counties.

3.157 According to our discussions with KPLC only 9 out of 49 KPLC administrative counties have border metering. The above implies that KPLC is neither able to hold staff in counties accountable for the power received in counties nor able to come up county specific loss reduction initiatives.

2. Substations and feeder metering

3.158 Substation and feeder metering is crucial in KPLC efforts to reduce power losses. This is because proper metering of feeders at substation level will allow for KPLC to accurately determine power losses at various levels of the grid and also for specific feeders.

3.159 From our discussions with KPLC, we understand that KPLC regional staff are assigned operational responsibility on feeder basis i.e. Operational staff at supervisor level are responsible for a given

number of feeders. With proper substation and feeder metering, it would be possible for KPLC to hold those supervisors responsible for pervasive losses in their assigned feeders.

3.160 According to the Facilities Database data that KPLC provided to us, the KPLC grid has about 376 primary substations. According to KPLC, about 255 (67%) of them are metered on the scada system. There are about 1,389 distribution feeders. These include 66 kV, 33 kV and 11kV feeders. Of these, 1,000(72%) are smart metered, 279(20%) are AMR metered while the rest 110(8%) are not metered.

3.161 KPLC needs to prioritise the completion of substations and feeder metering as this will enable KPLC to implement targeted efforts to reduce losses and also hold staff responsible for losses in their assigned feeders.

3. Transformers metering

3.162 For KPLC to be able to pinpoint the exact sources of commercial losses, then KPLC needs to meter the grid up to transformer level. This will allow for a reconciliation of the energy billed to the customers supplied by a particular transformer to the energy throughput of the transformer so as to zero in on areas with unusual discrepancies with a more targeted approach.

3.163 Currently, KPLC has about 8,778 distribution transformers i.e. 11/0.415kV and 33/0.415kV. We understand based on discussions with various persons at KPLC that distribution transformers are not metered.

3.164 If KPLC achieves significant transformer metering, KPLC will be able to effectively address commercial losses in a more targeted manner.

3.165 We however note that the above is a very capital-intensive process. From our discussions with KPLC management, transformer metering is among KPLC's long terms plans in tackling energy losses.

4. Customers

3.166 Customer metering is one of the most important aspects for any electricity distribution utility. The utility can only effectively collect revenue where its customers are properly metered. Thus, there should not be cases where KPLC supplies unmetered power as this directly translates to power losses.

3.167 KPLC has a record log of all projects commissioned, in progress and completed by various project managers. The projects are referenced and tracked by status and the number of customers to be metered are picked at design stage.

3.168 These projects are broadly grouped into:

i. Government funded schemes (GOK Last Mile Funded, Group Schemes, Funded REA, Street Light, People Settlements, KPLC Last Mile Funded and Child Funded) ii. Customer paying schemes i.e., customers paying fully for the services requested from KPLC. Some of these include customers applying for additional load, new large commercial customers (load > 1000 kVA), premium customer load (> 25 kVA) and those requesting for meter separation.

3.169 For government schemes once they are complete KPLC updates the status to complete in the system however there are instances where some customers are not connected to the supply because they have not done wiring for their premises. These customers are expected to contact KPLC once they are ready for connection while in some cases KPLC marketing teams keep going back to the schemes to check if the customer is ready. At closure the construction supervisor should put comments in the Integrated Customer Management System ("InCMS") system indicating readiness of customers to be connected to power however this is not always the case hence making it difficult for KPLC to track progress of these customers.

3.170 This creates a loophole for customers to illegally connect themselves later however KPLC carries out periodic snap checks to confirm that these customers are not tapping power illegally however this process cannot account for all customers who are potentially left unmetered.

3.171 We came across various reports at KPLC regarding unmetered connections as discussed below:

Rural Electrification and Renewable Energy Corporation ("REREC") projects

3.172 Before the enactment of the Energy Act 2009, the Rural Electrification Authority was tasked with spearheading the electrification of rural areas in Kenya. The Energy Act 2009 changed it to REREC.

3.173 REREC undertake rural electrification projects and then hands them over to KPLC for metering and energizing.

3.174 There however have been challenges in the above handover leading to unmetered connections. These are as follows:

i. **Customer connections without the involvement of KPLC**: According to Eng Oduor[14], the Substantive GM Commercial and Customer Service, REREC contractors have in the past connected customers to the grid without informing KPLC. These customers would remain unmetered until KPLC staff discover the improper connections.

ii. **Delays in Metering on the Part of KPLC**: There have been cases where KPLC has delayed the metering of REREC installations due to various reasons including the lack of meters. This has led to customers seeking unscrupulous dealers to connect them to the grid without meters.

iii. **Misaligned Targets for REREC:** We understand that REREC projects are only deemed as complete when the customer installations are connected to power. We however note that the metering of the installations is the responsibility of KPLC hence out of their control. The scenarios then motivates REREC contractors to make illegal connections to their installations so as to achieve their targets.

3.175 KPLC needs to align with REREC on the metering of customers to ensure 100% timely metering of REREC installations. KPLC and REREC should have in place a Service Level Agreement that should include an accountability framework so as to iron out the above noted issues.

3.176 KPLC also needs to streamline its meter procurement processes to ensure availability of meters for timely installation.

3.177 Further, KPLC should take action in cases where installations are connected to power without meters and without KPLC involvement. Direct power connections imply a direct loss of revenue by KPLC hence KPLC should take action on any parties that facilitate direct connection of customers to deter the vice. ***Street lighting projects***

3.178 Over the last several years, there have been numerous street lighting projects spearheaded by County governments.

3.179 According to KPLC's Technical Audit Report No. 06 - 2019/2020[15] - Street Lighting Installations - Nairobi West Subcounty And Kajiado County:

i. 119 installations (32.5% of sampled installations) were active (Using electricity) and not metered. Approx. Revenue loss KES 1.8M per month.

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[14] Appendix 13: Notes from our meeting with Eng Oduor.

[15] Appendix 14: KPLC's Technical Audit Report No. 06 - 2019/2020

ii. 145 meters were not billed due to wrong readings. Approx. delayed revenue collection of KES 32 M as at January 2020. iii. 72% of street lighting meters were not mapped with correct coordinates hence were not covered during meter reading.

3.180 Based on the job references data provided, there were 785 street lighting projects spread across the country that were marked as complete but only 14% of the projects were fully metered i.e., the number of commissioned meters was 154 out of 1085 contracted meters.

3.181 KPLC needs to increase vigilance over the street lighting projects to ensure that they are properly metered and the meters are read in a timely manner.

Informal settlements

3.182 From our discussions with management as well as some Regional operational staff, we understand that the electrification of informal settlements has been an area of concern for KPLC. KPLC has consistently experienced very high losses in feeders that supply power to informal settlements.

3.183 The following table summarise the losses in select 11kV feeders to informal settlements Informal settlements in Nairobi:

Feeder ID	Feeder Name	Average of % loss (2022 to Mar)	Feeder throughput (2022 to March)
208000178	Kayole	95%	7,052,800
208002349	Soweto Ex Langata	80%	7,092,000
208001538	Mathare North Ex Huruma	78%	6,091,840
208000763	Indigo Ex Babadogo	77%	6,419,680
208002917	Valley 11kv Ex Ruaraka Complex	76%	1,170,960
208001622	Muthurwa Mkt Ex Muthurwa	74%	2,519,200
208001540	Kiamaiko Ex Huruma	73%	2,152,240
208000772	Kibera	66%	6,648,720
208001948	Metameta 11kv Ex Ruaraka	59%	4,074,200
208000769	Kariobangi Ex Babadogo	57%	1,588,240
208000764	Dandora Ex Babadogo	51%	4,789,560
208001543	Light Industries Ex Huruma	46%	3,569,120
208002651	Kamukunji Ex Muthurwa	41%	8,045,680
208001539	Kamunde Road Ex Huruma	41%	2,861,840
208000768	Kenafric Ex Babadogo	27%	2,256,680
208001626	River Road Ex Muthurwa	26%	5,631,760
208001625	Otc Ex Muthurwa	25%	2,519,720
208002281	Lucky Summer Ex Babadogo	25%	7,453,080
208002007	Mukuru	24%	4,874,700
208002389	Sewage	21%	3,987,480
208002288	Rhino Park Ex Dagoretti	18%	1,261,320
208001621	Gikomba Ex Muthurwa	13%	2,912,840
208000023	K.C.C Dandora	11%	1,429,400

Table 42: Losses on feeders to informal settlements
Source: Our analysis of KPLC data

3.184 The situation is mainly attributable to:

i. **Numerous illegal connections in informal settlements** : During our field visit to Mathare informal settlement near the KPLC Ruaraka Complex substation, we observed the extent of the issue first-hand. Up to 98% of the structures had unmetered supply of electricity. We observed a 'local LV grid' made up of thin cables traversing the entire settlement.

We understand from KPLC that the situation is the same for all informal settlements in Nairobi.

ii. **Vandalism of KPLC meters and cabling**: We understand that KPLC metered various informal settlements with pole mounted meters to discourage meter bypasses. From our discussions with KPLC staff, we understand that all the meters and cabling were vandalised. We observed total vandalism of the said equipment pole mounted metering project equipment in Mathare settlement.

iii. **Operations of Cartels**: According to KPLC management, operations to remove illegal connections from KPLC infrastructure in informal settlements has in the past faced violent resistance. According to management, the illegal connections are controlled by violent cartels, making any clean-up operations dangerous to KPLC staff. Further, such operations would be fruitless as the connections would be returned as soon as KPLC staff leave.

3.185 KPLC has undertaken various initiatives beside the pole mounted metering to address the issue. These include:

i. Operations in conjunction with the police to clear illegal tapings from KPLC Low Voltage lines.

ii. Replacement of high kVA transformers that result in long Low Voltage lines with numerous low kVA transformers that supply legal customers using insulated cables that are harder to tap. The Hight Voltage lines to the transformers are dangerous and difficult to directly tap.

3.186 While this has been a difficult issue to deal with the world over, KPLC can consider and explore the following:

i. **Community metering**: KPLC can consider introducing community metering in informal settlements. KPLC can propose for the cost to be borne by the state as part of the state's empowerment programs.

ii. **Third party distribution:** KPLC can consider selling bulk electricity to a third party who can then distribute and manage the power to the informal settlements. KPLC would however have to cede considerable margins for such an arrangement to work. ***Government Funded projects***

3.187 Based on our data analysis on job reference data we identified 666,837 government funded projects which were marked as complete. Out of these 47,915 projects had potentially unmetered customers since the records indicate zero meters commissioned. Below is a breakdown of the work request types with their corresponding number of meters contracted vs meters commissioned.

Work Request Type	Contracted Supplies	Metered Supplies
Y - Child Funded (GOK Last Mile Funded)	47,119	0
Q - Street Light	749	0
S - People Settlements	2	0
D - Funded Rea	45	0
Total	**47,915**	**0**

Table 43: Work request types distribution of contracted vs supplied meters Source: KPLC Job reference data

3.188 In response to these potentially unmetered projects, Eng Kennedy Sunga Ogalo ("Eng Ogalo"), Manager, Power System, Design & Development, highlighted a number of reasons detailing why there were variances in the actual number of meters commissioned. These include:

i. Unavailability of some meter specifically 3-phase post-paid meters
ii. Customers requesting more meters than actually needed
iii. Customers not ready to take supply mostly because wiring in their premises is incomplete
iv. Customers relocating to a different premise before connection
v. Difficulties in accessing information in the old ICS system
vi. Meters meant for retrofitting not entirely captured as new installations
vii. New customers connected to old meters rather than new meters

viii. Inconsistencies between InCMS data and the data provided to us for analysis (data queried from the database by IT team not updated to reflect the actual number of meters installed)

3.189 KPLC needs to increase vigilance on customers who might be enjoying unmetered power especially customers under government schemes who have not submitted their wiring certificates (indicates customer readiness to be connected to power) to KPLC as they might have been connected illegally. Additionally, at closure the construction supervisor should put comments in the InCMS system indicating readiness of customers to be connected to power for easier tracking purposes.

c-2) Large customers and feeders without smart meters

3.190 According to a Paper[16] to the KPLC Executive Committee titled "KPLC Metering Roadmap"[17] that KPLC provided to us, it was proposed to have all Large Power Customers and feeders on smart

Meters on the AMI platform. This was aimed at revenue protection, revenue assurance and customer satisfaction.

3.191 According to records provided to us by the Customer Services and Sales Division, the KPLC Advanced Metering Infrastructure ("AMI") project was instituted in 2015 targeting 5,967 large customers.

3.192 The main objectives of the project, according to Mr Wanyonyi, the Ag Chief Engineer Sales, were:

i. Revenue protection: The smart meters were more accurate, had advanced tamper proof features and could be disconnected/reconnected remotely in case of customer default.

ii. Reductions of operational costs: The smart meters did not require manual reading or operation as they could be read and operated remotely.

iii. Customer Service: The smart metering platform could be accessed by customers who wished to monitor their power consumption.

3.193 The project involved retrofitting large customers with smart meters that were able to send data and receive instructions from a central control platform. The smart meters were superior to the then obsolete AMR platform and its associated AMR meters. The AMR meter could only transmit meter readings automatically before their platform expired.

3.194 In 2017, KPLC also procured 1000 smart meters for feeder metering. These were meant to replace AMR meters that had earlier been installed on feeders. According to Mr Wanyonyi, the Ag Chief Engineer Sales, KPLC elected to start the retrofitting with 33kV and 11kV feeders. Mr Wanyonyi explained that this was because most of the technical and commercial losses were observed in these lines. The above left most 66kV feeder on AMR meters which are barely read.

3.195 Similarly, some large power customers are still on the old AMR meters that have to be read manually following the expiry of the AMR platform. As of February 2022, there were 1,609 out of 8,205 large power customers on non-smart meters. These customers accounted for about 18.1% of the total units consumed by large power customers valued at approximately KES 19.7B for the year 2021.

3.196 Notably, of the 20 large power consumers, National Cement Company Limited (Account: 104842558), who was 14th largest consumers in 2021 was not on a smart meter. Other Large power customers who were not on smart meters include Keda (Kenya) Ceramics Company Limited, East African Portland Cement, Safepak Ltd and Kenya Pipeline Company Ltd. The table below lists the top 10 customers without smart meters in 2021 as well as statistics regarding the distribution of smart meters among large power consumers.

[16] Internal Audit did not confirm to us whether this paper was adopted by the KPLC Executive Committee by the time of this report.

[17] Appendix 15: Paper to the KPLC Executive Committee titled "KPLC Metering Roadmap

No.	Accnt No.	Customer Name		Total Units (Jan – Dec 21)	Value
1	104842558	National Cement Company Limited		35,710,080	614,978,472
2	75007480	Keda (Kenya) Ceramics Company Limited		35,521,115	663,259,366
3	5313549	East African Portland Cement		26,884,290	509,371,042
4	40329252	Safepak Ltd		19,034,579	374,037,841
5	5317250	Kenya Pipeline Company Ltd		16,644,384	298,404,106
6	5321021	Safepak Limited		16,003,137	315,924,520
7	15350085	Kenya Ports Authority		14,195,639	246,174,609
8	21090055	Nairobi Bottlers Ltd		14,190,819	286,125,502
9	106159361	Pembe Flour Mills Ltd		14,078,280	265,856,127
10	50761291	Authority Airports Kenya		13,173,594	243,451,444
	Others	1433 Accounts		501,530,016	12,034,664,206
	Total Non-Smart		1533	706,965,933	15,852,247,236
	Total Accounts		8,574	5,037,819,079	105,936,061,418
	% Non-Smart		18%	14%	15%

Table 44: Top 10 large customers without smart meters in 2021 and distribution of smart meters among large power consumers. Source: KPLC Data

3.197 Mr Wanyonyi , explained to us that some of the large customers are still on the now manual AMR because of:

i. Reallocation of smart meters to new customers: KPLC reallocated some of the initial smart meters to new customers. He explained that KPLC preferred installing the new smart meters on new customers instead of AMR meters that would need to be retrofitted down the line. ii. We noted 16 large power customers[18] who were in the initial list of customers to be retrofitted with smart meters that were not retrofitted. Notably, Safepack Limited had two meters in the initial plans that were not retrofitted.

iii. Budgetary constraints: The number of large power customers grew and exceeded the set of smart meters that KPLC had procured and since then KPLC had not procured additional smart meters due to budgetary constraints.

3.198 The Substantive GM, Commercial and Customer Service and former Acting MD and CEO, Eng Oduor, echoed Mr Wanyonyi 's explanation and also noted that some of the large customers could not be interrupted at the time the smart meter installations were taking place. She explained that by the time they were ready for installation, the supply of smart meters for their level of supply were already exhausted. Subsequently, KPLC has faced difficulties in obtaining additional smart meters due to budgetary constraints as well as procurement related litigations.

3.199 We note that Mr Wanyonyi was unable to provide approval for the decision to reallocate the smart meters to new customers or evidence of procurement requests for additional smart meters that were turned down due to budgetary considerations.

3.200 We noted that KPLC is currently retrofitting smart meters to some of the large power accounts. These include National Cement Limited, East African Portland Cement and Rai MDF Limited.

3.201 Having some large customers on manual AMR meters undermines the objectives of the smart metering project, particularly revenue protection, since KPLC is not able to monitor the power consumption on a real time basis. Further, the lack of smart meters on some feeders makes energy balance computation nearly impossible.

3.202 As per Mr Wanyonyi, the approximate cost of smart meters is as below:

Type	Inclusions/exclusions	Cost (Kes)
Low voltage CT meter (2000/1500/1000/500/300/200/5 A)	smart meter, CTs and Breaker	550,000
11kV indoor	PT, CT, Breaker, Protection relays	2,000,000

[18] Appendix 16: List of 16 Large power customers in initial list of customers to be retrofitted with smart meters that were not retrofitted.

11 kV outdoor	PTCT, Breaker, Protection relays	1,500,000
S/S Metering (33kV/ 66 kV/ 132 kV/ 220 kV) (Large Power AMR Replacement)	Meter and case only	150,000

Table 45: Approx. cost of smart meters Source: KPLC

3.203 Whereas we note that budgetary constraints were cited as an issue, going by Table 45 above, the likely cost savings from reduced power losses particularly with respect to the large power consumers, are likely to more than offset the initial investments based on our findings regarding the extent of commercial losses.

c-3) Lack of consistent meter readings

3.204 We observed that KPLC does not prioritise reading, collating and analysis of non-customers meters (feeders meters) that are not on the smart platform. This is possibly because internal meters and their readings have no immediate commercial implications like those of customers.

3.205 Due to this lack of focus on internal meters, KPLC does not have a system or a structured mechanism of taking the feeder and transformer meter readings and recording the meter reading. To a large extent it appeared that this is left at the discretion of the field teams that oversee the feeders and the transformers. These meters are useful for energy accounting within the distribution network and will help in segregating the losses so that technical losses and commercial losses can be adequately apportioned.

3.206 A KPLC Internal Audit report No RA-2020/2021-04[19] dated 5th Mar 2021 on Energy Loss Reduction highlighted the major issues as follows:

i. Lack of focused resource to follow up on identified initiatives on loss reduction initiatives particularly with feeders
ii. Large customers are still on non-smart meters such as KEDA and National Cement in Nakuru
iii. Lack of progress monitoring and recording of the customer alignment to transformers and feeders
iv. Lack of adequate feeder metering (70% equivalent to 765 feeders out of 1165 which are metered are on smart metering)
v. Inadequate follow up on identified issues hampering feeder performance analysis like delayed or non-reading of feeder meters or replacement of faulty feeder meters

3.207 These issues lead to incorrect estimation of transmission losses and inaccurate simulation of technical losses in the distribution network. The net result is that when KPLC computes the commercial losses, they are deemed to be inaccurate and misleading therefore lack of ownership.

3.208 The lack of focus on feeder metering and reading was apparent in our analysis of two 33KV feeders feeding the Machakos substation, one from Konza and the other from Katoloni. KPLC did not avail to us all the feeder meter consumption data for the Machakos 33KV Feeder ex-Katoloni following our request, an indication that the data may not be collected consistently month on month.

3.209 The feeder emanates from a Ketraco owned Substation. Thus, the meter at the source of the Feeder
and the data thereof are under the custody of Ketraco. Further, Ketraco, not KPLC, decides what type of meter to install in such feeders. KPLC has to therefore liaise with Ketraco to obtain the data from such meters. As summarised in Table 46 below, KPLC was unable to provide consistent data over a 5 month period. We understand that the Machakos 33KV Feeder ex-Katoloni is the preferred feeder to supply Machakos Substation because of the shorter length (about 7 km). The Ex Konza line is about 26 km long.

[19] Appendix 17: KPLC Internal Audit report No RA-2020/2021-4

3.210 This hindered our ability to conduct a complete energy balance analysis at the Machakos substation. Without the ex-Katoloni data[14] the analysis was showing a power gain at the substation which is not practical as shown in the table below: We had been informed that it is the preferred feeder to supply Machakos Substation because of the shorter length of only about 7 km. The Ex Konza line is about 26 km away.

Month	Machakos 33 Kv Ex Konza	Machakos 33 Kv Ex Katoloni	Outgoing Feeders	Difference
Nov 2021	1,638,120	Not Provided	4,385,960	2,747,840
Dec 2021	2,919,240	73680	4,421,400	1,428,480
Jan 2022	1,444,920	Not Provided	4,001,520	2,556,600
Feb 2022	2,032,800	Not Provided	4,560,000	2,527,200
Mar 2022	4,618,680	Not Provided	4,359,400	(259,280)
	12,653,760		**21,728,280**	**9,074,520**

Table 46: Incoming/Supply feeder KWH for Machakos substation Source: PwC Analysis

3.211 Our attempt at carrying out a similar energy balance calculation at JKUAT 66KV substation met with a similar experience. The JKUAT 66KV Feeder has a smart meter and there are no transformers on the 13.2 KM line between Mangu substation and the JKUAT substation. The 11KV outgoing Feeders from the JKUAT substation also have smart meters. However, we could not reconcile the energy input and the output from the station because the smart meter at Mangu indicated a much lower figure compared to the sum of the four outgoing feeders. We could not determine the Line Load factor and hence technical losses could not be ascertained. The table below shows the noted variance.

	Juja Town 11KV ex JKUAT (208002191)	JKUAT 11KV ex JKUAT	Kiaora 11KV ex JKUAT (208002193)	Industrial 11KV ex JKUAT (208002188)	Total Ex JKUAT	JKUAT ex Mangu 66KV	Variance
Mtr No	4002000478	4002000479	4002000450	4002000452		4002000888 2,517,120	
May-22	2,673,780	267,180	791,100	1,950,540			(3,165,480)
Apr-22	2,639,340	258,240	712,680	1,985,220	5,595,480		
Mar-22	2,644,320	298,320	879,840	2,155,020	5,977,500	3,895,920	(2,081,580)
Feb-22	2,433,180	269,340	814,740	2,036,580	5,553,840		
Jan-22	2,567,100	246,120	789,540	2,205,840	5,808,600		

Table 47: Energy balance calculation at JKUAT 66KV substation Source: KPLC Data, PwC analysis

3.212 According to KPLC, the meter on JKUAT ex Mangu 66KV (04002000888) had incorrect configurations hence wrong readings.

3.213 The failure to take and analyse non-customer meter readings means that KPLC is unable to monitor its distribution network effectively and puts to question the value derived from investing in such meters.

c-4) Use of meters classes with a high margin of error

3.214 The class of a meter denotes the level of accuracy of the meter. The number denotes the percentage level of error of the meter and as such, the lower the class number, the more accurate the meter. A class 0.2S meter has a 0.2% level of error and is thus more accurate than a class 1.0S meter that has an error level of 1%.

3.215 From our review, we noted that KPLC power generation meters are of class 0.2S and customer meters are spread across classes 0.2S, 0.5S and 1.0S. KPLC should aim for class 0.2S meters especially for large power customers metered at high voltages.

3.216 During our larger power logging exercise, we noted error of measurements of -2.2% in a cement company and -1.8% in a steel company despite the customers being on class 0.2S meters whose expected maximum allowable error is +/- 0.2%. Our comparison of power loggers to customer meters showed underbilling of the customers. Given the noted consumption per annum of the two customers, a -2.2% and a -1.8% variance translates to a potential loss of KES 14.7M and KES 11.1M respectively, per annum. KPLC thus needs to routinely calibrate their meters to ensure that they maintain the required accuracy.

3.217 Given the critical nature of metering to KPLC revenue, KPLC should enhance the surveillance of metering accuracy through regular meter calibration. A cost benefit analysis of frequent calibration should be weighed against the reduction in commercial losses and the potential protection of revenue, especially for the large customers.

3.218 Further, KPLC has established that the maximum error to replace meters is 3%. KPLC did not clarify the basis for this. The 3% error allowance for large power customers can lead to very high losses keeping in mind that a 1% error for KPLC potentially implies a KES 1B variance in revenue based on the prevailing cost of power.

3.219 According to IEC standards 62053-212020 and 62053-22-2020 which establishes the maximum error on meter classes, the highest acceptable error in class 0.2S is 0.4% and in class 1.0S is 1.5%. KPLC should adopt the IEC standards for the replacement and recalibration of meters.

iii) Significant power losses in some regions, and or on some feeders

3.220 As per KPLC's Facilities Database ("FDB"), KPLC's distribution feeder network has about 1,389 feeders. These consist of 11kV, 33kV and 66kV feeders.

3.221 We understand that KPLC has 66kV feeders mainly in major urban areas and 33kV feeders in rural areas. While 66kV feeders are concentrated and ringed to form a grid, 33kV feeds are singular and longer, traversing vast areas.

3.222 About 92%(1,279 of 1,389)) of the distribution feeders are metered, with 72%(1000) on smart meters and 20%(279) on AMR meters. smart meters transmit their readings automatically to the C&I system and AMR meters require manual reading. About 49%(685 of 1,389) of distribution feeders have smart meters that are transmitting data as expected. This is about 69%(685 of 1000) of the total smart meters installed on feeders. We note that most AMR feeder meters are not consistently read.

3.223 According to Eng Mwangi, the Ag GM Network Management, those meters are not read because:

i. In the past, no one needed the information
ii. There is shortage of resources, especially manpower to read and store the data

3.224 Based on the information that KPLC provided to us, we undertook an energy balance reconciliation at feeder level for 2021. The following table summarises the results:

Voltage	Total feeders	Smart & (Working) meters	% Smart working meters	'> 50 pct Loss	10-50 Loss	0-10 pct Loss	pct -ve Loss	% > 50 pct Loss	%10-50 pct Loss	% 0-10 pct Loss	% -ve Loss
11 kV	988	555	56%	116	213	35	191	21%	38%	6%	34%
33 kV	307	128	42%	80	32	1	15	63%	25%	1%	12%
66 kV	94	2	2%	2				100%	0%	0%	0%
Total	1,389	685	49%	**198**	**245**	**36**	**206**	29%	36%	5%	30%

*Table 48: 2021 Energy Balance reconciliation at feeder level Source: PwC Analysis of KPLC ****

3.225 We attached a detailed breakdown of the feeder losses as an appendix[20].

3.226 The analysis shows that the loss on some feeders is significantly high while on others the loss is lower than expected, in some cases falling in the negative. The losses could be attributable to several factors including:

i. **Power theft**: Significant positive variances, i.e. where power billing is significantly lower than the feeder throughput, can be an indicator of possible power pilferage due to illegal connections and meter bypasses. This is especially the case where the feeders in question supply to high risk areas.

Examples include the Kariobangi-ex-Babadogo _ID 208000769 with average variance of 52%, Valley 11kv Ex Ruaraka Complex _Id 208002917 with average variance of 76% and Kiamaiko Ex Huruma_id 208001540 with an average variance of 73%.

Due to scope and time constraints, we were not able to undertake further review into such cases. KPLC should investigate the causes of such high variances.

ii. **Inaccurate mapping of customer supply points**: Various reports at KPLC indicate that a sizeable number of customer supply points are not accurately mapped to the right feeders. This is especially the case with prepaid meters that do not require meter reading. Further, customers can easily move prepaid meters between supply points without the knowledge of KPLC.

KPLC commissioned the NYS project in July 2021 to geolocate Low Voltage Infrastructure and customers meters. The exercise is expected to address the customer feeder mapping issue. We understand that the project is ongoing. Further, according to KPLC Internal Audit Department, as of March 2022, the acquired data had not been utilised due to inaccuracies observed in the data that needed to be cleaned up

iii. **Grid interconnectivity for redundancy:** From our discussion with the Network team, we understand that most of the network is interconnected to ensure uninterrupted supply of power. This is manly achieved by having open points between feeders to ensure power supply even when there are faults in certain feeders or repair works. This interconnectivity and open points mean that the above data cannot be used to determine commercial losses other than in cases where a feeder is singular.

Given that the open points are not metered, the power supplied to the customers mapped to a given feeder does not necessary mean that it was metered through the given feeder. iv. **Inaccurate feeder meter CT and PT ratios**: From our discussions with Eng Angira , an Assistant Systems Planning Engineer, we understand that due to the low priority nature of feeder meters, there are cases where the CT and PT ratios are not set correctly. This leads to inaccuracies in the meter readings.

3.227 We further grouped the feeders in the Nairobi region to assess if the losses are influenced by the demographics of the areas where they supply. We grouped them into informal settlements, formal settlements, and commercial zones. Nairobi is the region with the highest absolute distribution losses. The table below summarises the outcome of that analysis.

3.228 The grouping was informed by the KPLC feeders names and our knowledge of the Nairobi populations demographics. The grouping is thus prone to some errors particularly in cases where the feeder names do not match areas where they supply power or where KPLC's and our assumptions on the population demographics in a particular area are inaccurate. The table below summarises the outcome of that analysis for the first three months of 2022.

[20] Appendix 18: Breakdown of feeder losses

Demographic Classification	Throughput	Billing	Variance	Implied proportion	Loss
Commercial		242,070,861	32,978,989		12%
Formal Settlements		220,915,625	25,076,009		10%
Informal Settlements	83,241,980	50,330,422	32,911,558		40%
Unclassified	24,369,900	22,285,987	2,083,913		9%
	628,555,790				
Total		**535,602,895**	**93,050,469**		**15%**

Table 49 Feeder loss analysis by demographics Source: Our analysis of KPLC data

3.229 The analysis showed that significantly high proportion of losses for feeders supplying areas around known informal settlements. The data also showed high variances for feeders supplying areas near known commercial areas.

3.230 Due to scope and time constraints, we were not in a position to further investigate the feeder losses to establish which of the factors in 3.226 above could be contributing to the losses. We recommend that KPLC investigates the feeders[21] with exceptionally high or low losses to establish the cause of the loss and take appropriate remedial action.

3.231 We also note the lack of smart metering of the 66kV lines. Given their significance and the fact that they supply some of KPLC's largest and high-risk customers, their metering should be prioritised.

3.232 As part of our review, we identified a 33kv smart metered feeder, Steel Mills Ex Kikuyu (ID 208000746), that only supplies one customer (Palak International Ltd - 15321284) and does not have an open point to other feeders. Palak International Ltd as a customer does not have a smart meter.

3.233 The following table summarises the reconciliation of the power throughput according to the feeder meter to the power billed to the customer.

Year	Feeder Throughput (kWh)	kWh Billed	Power Loss	% Loss	Amount billed
2018	10,427,200	10,328,458	98,742	0.9%	186,888,098
2019	15,798,040	15,877,911	(79,871)	-0.5%	305,586,435
2020	14,265,680	14,136,557	129,123	0.9%	265,608,569
2021	9,343,960	9,382,322	(38,362)	-0.4%	196,623,192
2022 (To Mar)	370,240	368,104	2,136	0.6%	10,537,311
Total	**50,205,120**	**50,093,352**	**111,768**	**0.2%**	**965,243,605**

Table 50: Summary of reconciliation Feeder meter reading to customer billing for Palak international Ltd) Source: KPLC Data

3.234 We note that the annual variance fluctuated between –0.5% and 0.9% and averaged at 0.2%. The negative variance is likely attributable to the timing of meter readings as well as the difference in meter classes. Nevertheless, considering that the feeder is quite short, the 0.2% loss is reasonable.

3.235 Further, there is notable drop in power consumption, from 15.8M kWh in 2019 to 9.3M kWh in 2021 (41% drop in 3 years). It would be important for KPLC to find out whether the drop is attributable to a drop in production or otherwise especially given the absence of a smart meter.

3.236 We further recommend that similar reviews be undertaken where feeders supply only one or a few large customers.

South Nyanza region loss analysis

[21] Appendix 19: Feeders with high losses

3.237 We carried out an energy balance analysis of the South Nyanza region which had the highest system loss by percentage averaging 44.69% between 2020 – 2022 of the 8 administrative regions to establish the potential causes and the sections where the losses occur. For this analysis, we utilized data from the month of February 2022 as it was readily available. The analysis is as shown in the tables below.

Description	Units (kWh)	%
132 kV (At Kegati)	22,076,000	
Feeders (Borders)	3,393,611	
Total Receipts	**25,469,611**	
Customer Metering/Bills	15,249,939	59.90%
System Loss	**10,219,672**	**40.10%**
Transmission Losses	1,800,452	7.10%
Distribution + Commercial Losses	**8,419,220**	**33.10%**

Table 51: Analysis of South Nyanza feeder losses
Source: PwC analysis of KPLC data

3.238 The table below further breaks down the loss into the various sections of the South Nyanza grid.

Section	Loss (kWh)	%
Kegati Substation	1,411,360	13.81%
Kegati - Kisii - Kilgoris Section	4,048,654	39.62%
Kegati - Awendo - Ndhiwa Section	4,759,658	46.57%
System Loss	**10,219,672**	**100.00%**

Table 52:Breakdown of South Nyanza system loss in the various sections of the grid.
Source: PwC analysis of KPLC data

3.239 The analysis showed that in the month of February 2022, the system loss in the South Nyanza region as a percentage of the energy received in the region was 40.1%. 7.1% and 33.1% of these were transmission and distribution losses, respectively. The analysis further showed that 13.81%, 39.62% and 46.57% of the losses occurred at the Kegati Substation, Kegati - Kisii – Kilgoris, and Kegati - Awendo - Ndhiwa sections respectively.

3.240 From our discussions[22] with the KPLC South Nyanza regional team, they noted that the losses above are attributable to heavily loaded transmission lines and heightened power pilferage in the region attributable to unmetered connections and meter bypasses.

3.241 KPLC should consider targeting further investigative procedures and loss reduction interventions to these sections that our analysis identified as contributing to the losses. It will also be useful for KPLC to broaden the analysis to other months that we were not in a position to analyse in the limited time available.

3.242 We observed that South Nyanza is a predominantly rural area with few large customers. The distribution losses are therefore likely to be because of feeder technical losses or unmetered consumption spread over a large population of consumers. Based on the discussions with KPLC we understand that the region has benefitted greatly from the rural electrification projects by REREC which as earlier mentioned are prone to metering delays. This could be amongst the contributing factors.

3.243 KETRACO commissioned sections of the transmission grid in the region as from 2018 which means it is relatively new. System losses reduction were among the benefits expected from the new transmission lines. KPLC should investigate why the transmission losses persist and pursue suitable remedial actions with KETRACO.

[22] Appendix 11: Notes from our meeting with KPLC South Nyanza team

iv) Customers with unusual consumption and billing patterns

3.244 Our review and analysis showed several patterns and anomalies that point to possible unbilled usage by consumers that would contribute to the overall system losses. KPLC needs to investigate these areas in more detail to establish if there is evidence of unbilled power usage and institute recovery measures from the concerned consumers.

3.245 We summarised these patterns and anomalies below, and discuss them in more detail in the sections that follow:

a. Unusual increase and decrease of power consumption
b. Increase in power usage after installation of smart meters
c. Variances in re-computation of large customers' bills
d. Debtors aging
e. Discrepancies between our independent power consumption measurements and the KPLC meters
f. Prepaid customers consuming units of low amounts

3.246 We discuss the various patterns and anomalies in the paragraphs below.

a) Unusual increase and decrease of power consumption

3.247 From our analysis, we noted cases of large power customers who showed abnormal power consumption patterns. These included significant jumps or drops in consumption in the reviewed period. As we note above we were not in a position to fully investigate these patterns and anomalies in the time available and given the scope of the engagement. We did preliminary high-level reviews and have included the observations that we made in the table.

3.248 We discuss some of the patterns below:

a-1) Significant increase or decrease of power consumption

Customer Name	Account Number	Period	Previous 3 Months (kWh)	Next 3 Months (kWh)	Difference (kWh)	% Change In Consumption	Comments
Jumbo Steel Ltd	91994909	March 2021	571,466	2,414,848	1,843,382	323%	• The customer had a meter change in March 2021 from 040016110734 to 040016113779. • There was a change in both CT and PT ratios on the same period • After this changes, an increase in consumption was recorded • After enquiring, Mr Felix Juma ("Mr Juma") Internal Audit KPLC explained that the customer had applied for a load increase in Jan 2018 • Mr Wanyonyi stated that Construction project to ensure the load increase supply began later on and was completed in April 2020. • Due to COVID, the customer was not ready to pick up the load increase then. • The load increase was picked in March 2021 and that's why there was an increase in consumption since the customer had an increase in production • The meter change was necessary for the meter that was there could not support the increased load. • Customers load application letter Ref. No. A21202019010002 provided
Silver Star Ltd	10533438	October 2019	18,272	39,892	21,620	118.32%	• The customer had a meter change in October 2019 from 040016110640 to 040013031675 • The meter change had a corresponding increase in consumption • According to KPLC's Mr Peter Wanyonyi , The customer had applied for load increase in 2019 • The increase in consumption is due to load increase • A meter change was necessary. Changed from Smart LV meter to High Voltage Meter.

Biashara Master Sawmills Ltd	81693275	May 2020	92,924	269,421	176,497	189.94%	• The customer had a meter change in May 2020 from 040016113617 to 040010111664 • The meter change had a corresponding increase in consumption • According to KPLC's Mr Peter Wanyonyi , the customer had applied for load increase. • The increase in consumption is due to load increase

Customer Name	Account Number	Period	Previous 3 Months (kWh)	Next 3 Months (kWh)	Difference (kWh)	% Change In Consumption	Comments
							• A meter change was necessary. Changed from smart meter to High Voltage AMR Meter. • At that moment, only an AMR 33kV meter was available. Hence the change to Non-Smart
Mombasa Cement	32623678	June 2020	5,469,968	11,972,920	6,502,952	118.88%	• The customer had a meter change in Feb 2020 from 040016110730 to 040016110748 • The meter change had a corresponding increase in consumption • The customer had applied for a load increase in 2018. • The increase in consumption was due to the increase in load
MS Grain	21121850	November 2020	322,723	490,857	168,134	52.10%	• The customer had a change from a smart LV meter no 040016112994 to Non smart meter No 040013031840 • The customer had applied for a load increase • Uprating this customer was because of the load increase application hence the meter change • Only an AMR meter that could support the uprate was available • There was an increase in consumption after the meter change
Associated Battery Ltd	102490828	July 2019	92,610	322,665	230,055	248.41%	• The customer changed from a meter no. 040010111857 to Meter No. in 04001303584 • The reason for change is recorded as due to a faulty meter • There is no explanation given as to why there was an increase in consumption
Limited Comply	15330657	June 2021	111,657	408,332	296,675	265.70%	• The customer had a spike in consumption in June 2021 • No explanation was given as to why there was an increase in consumption in that period.
National Cement Company Limited	32249880	April 2021	3,126,064	6,183,040	3,056,976	98%	• Had an increase in consumption in April 2021
Devki Steel Mill Ltd	5320148	May 2021	531,624	3,488,114	2,956,490	556%	• Had an increase in consumption in May 2021

National Cement Company Limited	104842558	April 2021	1,219,700	2,825,980	1,606,280	132%	• Had an increase in consumption in April 2021
Liquid Telecommunications Kenya Ltd	73434837	May 2021	12,152	912,444	900,292	7409%	• Had a significant increase in consumption in May 2021
Great Kenfast Works Ltd	29648755	April 2019	38,564	852,144	813,580	2110%	• Had a significant increase in consumption in April 2021
Abyssinia Iron And Steel Ltd	103791838	March 2021	176,913	287,788	110,875	63%	• Had an increase in consumption in March 2021

Customer Name	Account Number	Period	Previous 3 Months (kWh)	Next 3 Months (kWh)	Difference (kWh)	% Change In Consumption	Comments
Timsales Ltd	5311220	August 2018	28,047	18,966	(9,081)	-32%	• Had a significant drop in consumption in August 2021
Palak International Ltd	15321284	March 2018	1,118,916	184,859	(934,057)	-83%	• Had a significant drop in consumption in March 2018
Kenya Railways	75336747	May 2020	100,085	6,024	(94,061)	-94%	• Had a significant drop in consumption in May 2020
Devki Steel Mill Ltd	23397458	March 2021	1,222,062	77,790	(1,144,272)	-94%	• Had a drop in consumption in March 2021

Table 53: Large customers with significant increase and decrease in power consumption
Source: Large power billing data (201807-202205)

a-2) Devki Group

3.249 We noted several accounts that belong to related companies that had unusual power consumption patterns. The said accounts included accounts belonging to National Cement Limited and Devki Steel. These companies are informally referred to as Devki Group.

3.250 From our analysis, we noted that four of the Devki group accounts appeared to show a sudden and unusual increase in power consumption around May 2021. This is illustrated in Figure 6 below.

3.251 Notable among these was the case of Devki Group of Companies namely: National Cement Company Limited (Accounts 104842558, 32249880) and Devki Steel Mills (account 5320148) that had a sharp increase of consumption in the review period as shown in the figure below:

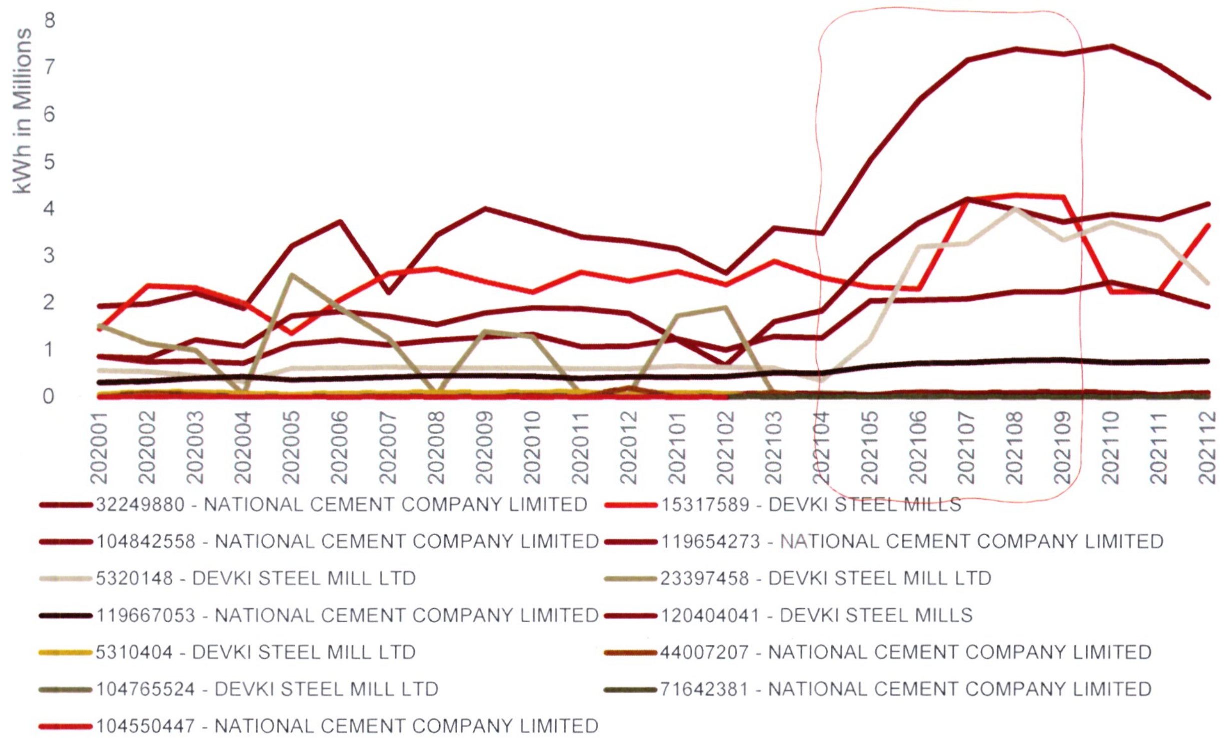

Figure 6: Devki Group of companies power consumption analysis
Source: InCMS large consumers billing data

3.252 Between March 2021 and August 2021, the power consumption by the three entities more than doubled from 5.8M kWh to 15.4M kWh respectively which in monetary term translates to an increase of KES 142M.

3.253 KPLC indicated to us that the jump in consumption for Devki Group coincided with an internal KPLC investigation into the Devki Group power consumption following suspicious patterns on the feeder and meter readings.

3.254 According to KPLC, an internal analysis had showed that for instance while one of the Devki Steel meter's recorded significant drops in load at night, the feeder meter supplying it would not have such drops. A corresponding drop was expected on the feeder meter because Devki steel was the main and highest consumer on the said feeder.

3.255 Our analysis of KPLC data on the Devki Steel plant in Ruiru, Kiambu County (Account 15317589) showed the said pattern. The consumption recorded by their meter (Meter 040016110311) would dip to near zero at night as shown in Figure 2 below. This trend would reverse during the day.

3.256 Given that KPLC incentivises large consumers to produce at night or off-peak hours when there is lesser demand for power through lower tariffs, it is thus unusual for Devki Steel to be consuming more during daytime instead of night-time.

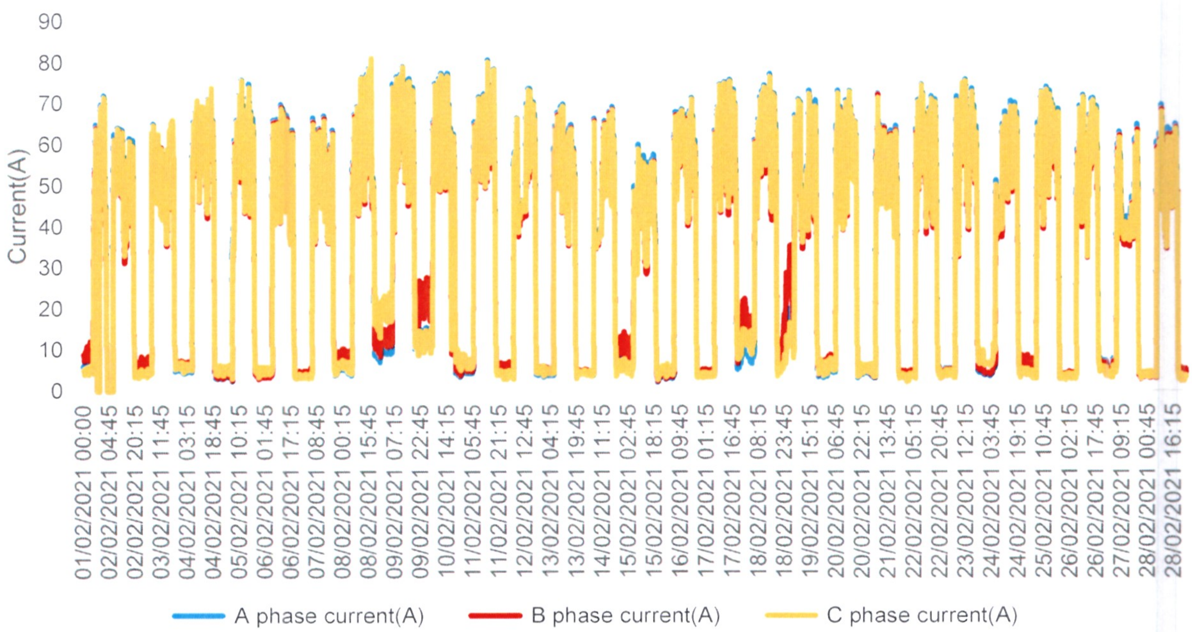

Figure 7: February 2021 Devki Ruiru load profile
Source: KPLC Data

3.257 We observed this trend from the start of our review period, January 2019, meaning it is possible this trend may have existed in the period prior to our review period. The trend however reversed and normalised after KPLC installed power loggers on the overhead cables (around May 2021) with the meter registering more consumption at night and lesser during the day. This is as illustrated under Figure 3 below.

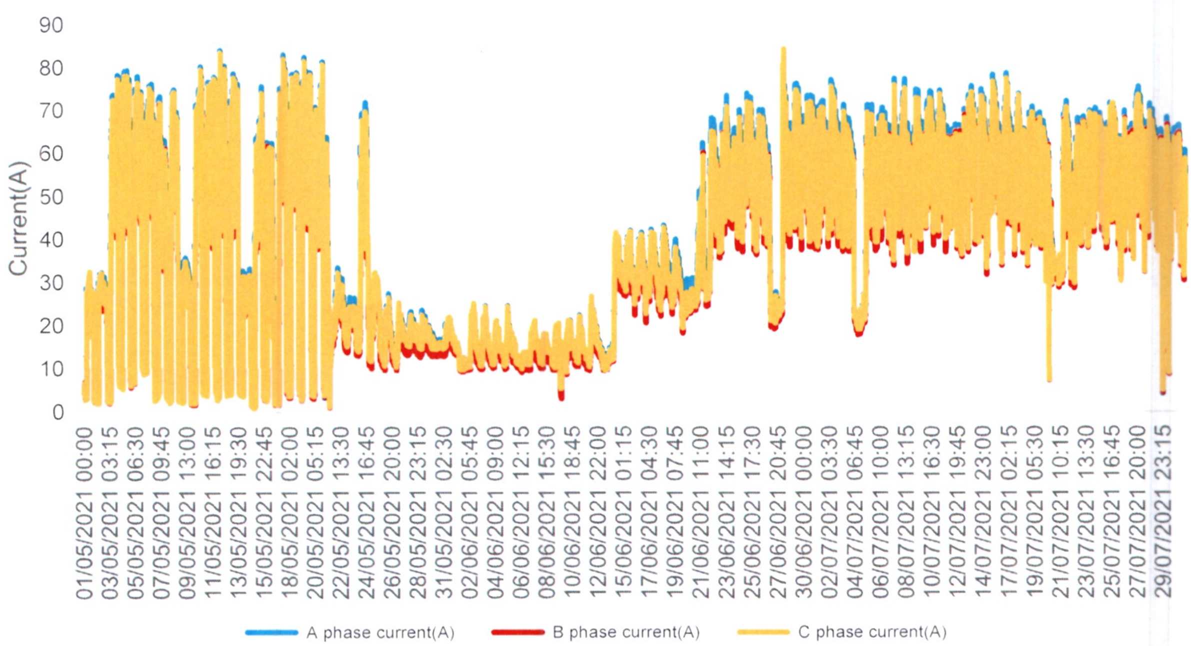

Figure 8 : Change in load profile for Devki Ruiru plant after instalation of power loggers. Source: KPLC data

3.258 The load levels on the 66 kV feeder from the KPLC Thika Road substation that feeds the Devki Steel plant in Ruiru did not exhibit the dips at night noted above. Since Devki Steel is a large customer on the feeder (it accounts for about 20% of the feeder load), it is expected that the feeder would exhibit similar load patterns as the meter. Since it did not, it implies that the feeder was delivering similar power load during the day and night which is inconsistent with the meter reading at Devki meter (Meter 040016110311).

3.259 While the above pattern could have been due to a drop in production, it could also possibly be an indicator of electricity underbilling as the KPLC investigation suggested. There is thus a need for KPLC to investigate these and other customers some of who we have listed in the tables above that had significant increases or decreases of consumption in the review period.

a-3) Other notable accounts

3.260 Limited Comply Ltd: Account Number 102738030; Meter Number 040016113779

Consumption increased more than four times in August 2021 after comparing it to the previous bills. We compared the customers consumption over a period of two years where we observed year 2020 and 2021, their consumption had increased by 275% over the period.

3.261 Kenya breweries Limited: Account Number 102738030; Meter Number 040016117850

Consumption showed anomalies with zero readings on the meter and an abnormal spike in consumption. Between June 2020 and Feb 2021, and between June 2021 and August 2021 the meter registered zero readings. The bill increased from zero in August 2021 to KES 10.7M in December 2021.

3.262 Silver Star Manufacturers Ltd: Account Number 10533438; Meter Number 040013031675

Since December 2019, consumption had been increasing with each billing period. The customer was initially on a smart meter Number 040016110640 up to October 2019 when KPLC changed the meter to the current non smart meter. After the change, there was an increase in consumption. We made a comparison between 2019 bill and 2020 bill where we established that there was an increase by 950%. The 2021 total bill compared to 2020 total bill shows a further increase of 92%.

3.263 Biashara Master Saw Mills: Account Number 6033614; Meter number 040010111664

Consumption in 2021 showed a substantial increase compared to prior periods. The customer initially had a smart meter number 040016113617 which KPLC replaced with the current non-smart meter in May 2020. After the change, the consumption increased significantly. Between 2020 and 2021, the consumption increased by 336%.

There is a need for KPLC to further investigate the causes of the above noted unusual movements to establish whether there is a reasonable explanation or whether they may point to cases of power under billings.

b) Increase in power usage after installation of smart meters

3.264 We obtained large power customers data and mapped it on smart meter master data to identify customers who had smart meters installed in the period under review. We performed analytics to identify large customers whose consumption spiked immediately after installation or replacement of smart meters and consumption remained high for more than 3 months post the installation period. We calculated three months consumption average before installation of smart meters as well as 3 months average consumption after installation of the smart meters.

3.265 From our analysis, there was a general consistent upward trend or spike in consumption after installation of the smart meters. Some accounts continued the upward trend of increased unit consumption while others normalized to their average consumption prior to the installation.

3.266 The table below gives a sample summary comparison of how the 3 months average revenue increased after installation of smart meters. The table contains average revenue that was been collected before installation of smart meters versus the average revenue collected after installation of the smart meters in different financial years.

Financial Year	No Of Accounts	Average Units before Installation	Average Units after Installation		Revenue Before Installation (KES)	Revenue After Installation (KES)	Revenue Increase (KES)	% Increase
2019/20	4	149,003	380,752		3,327,875	6,871,906	3,544,031	106%
2020/21	56	893,423	1,513,243	20,258,798		36,754,237	16,495,439	81%
2021/22	8	176,528	217,165		4,059,970	5,214,132	1,154,162	28%
Total	**68**		**2,111,160**	**27,646,643**		**48,840,275**	**21,193,632**	

Table 54: Summary of power consumption before and after installation/replacement of smart meters
*Source: *Large Power Billing Data, *Smart Meter Log list Data*

3.267 Some of the customers with significant increases in consumption are tabulated in the table below:

Customer Name	Customer Number	Installation Date	Previous Three Months (kWh)	Following Three Months (kWh)	Difference (kWh)	% Change in Consumption
Kimunye Tea Factory Company Ltd	710177	21-02-20	119,468	342,682	223,214	187%
Moi Teaching & Referral Hospital	2697639	11-05-21	54,489	172,189	117,700	216%
Ecoeri Green Co. Ltd	10847563	11-05-21	38,362	91,576	53,214	139%
Astral Industries Limited	7852932	22-10-20	25,132	51,360	26,228	104%
Xinhua New Agency	10828133	23-11-20	12,142	29,069	16,927	139%
Ministry of Energy	4135998	22-12-20	3,897	17,289	13,392	344%
Rob Flowers (K) Limited	6429842	28-09-20	2,319	12,575	10,256	442%
Tambuzi Limited	7314751	14-06-21	441	7,679	7,238	1641%
E.A Satsang Mandal	2072192	11-10-19	6,060	12,219	6,159	102%

Table 55: Customers with Spikes After Installation of smart meters
Source: Large Power Billing Data, Smart Meter C&I Data

3.268 KPLC should investigate the likely reason for the spike and if evidence suggest that there was unbilled power prior to the installation of the meters, recovery should be considered.

c) Variances in large customer bills after our re-computation

3.269 We reconciled[23] large customers billing data and we independently recomputed the bills for each billing cycle in the review period as well as applying the prescribed discounted rates[24] and the gazetted monthly pass-through rates[25]. Based on our re-computations we identified 1,697 accounts whose bills had variances between KPLC bills and independently recomputed bills with the variances exceeding KES 10,000.

3.270 We held consultations with Eng. Peter Wanyonyi, Ag Chief Engineer Sales and Commercial Services and Eng. Joseph Njoroge, assistant engineer Sales and noted the following as the possible causes of the highlighted variances:

i. List of customers considered to be operating at 100% production capacity - Data provided only from February 2019 to March 2022. This posed a challenge because we could not determine which companies were eligible to the discounted rates (these customers are eligible to a 5% discount on the applicable energy rate in respect to the schedule of tariff 2018[26]) for the missing data from July 2018 to Jan 2019 and this might result in variances.

ii. Erroneous calculation of thresholds by the KPLC system however Eng. Peter reiterated that these cases were noted and improvements made in future computations. A case scenario

[23] Appendix 20: Customer bill reconciliation and debt aging procedures.
[24] Appendix 21: Flow chart for TOU final 040818
[25] Appendix 22: Monthly Pass-Through Rates
[26] Appendix 23: Revised yellow book

was ICIPE-MBITA POINT[27] (Account Number 22440184) had wrongly computed 6 months thresholds for periods Jan 2021, November and December 2020.

iii. Tax exemptions for certain customers e.g., customers operating in Export Processing Zones (EPZs).

iv. Exclusion of PF surcharge to power producers including Independent Power Producers ("IPPs"). We also noted that for some independent power producers there were certain periods they were charged the surcharge while in other periods they were not charged. A case scenario is Biojoule Kenya Limited (Account Number 48414007) which was charged in July 2020 (KES 168,214) and April 2021 (KES 338,771) however they were not charged for other periods falling in our review period (July 2018 to March 2022). Additionally, KenGen (TURKWEL) Account Number 22120752 were charged a total amount of KES 10,013 in September 2019 but no charges for the rest of the period.

v. Prorating of consumption i.e., customers who were moved from one tariff to another during a particular billing period. A case scenario was HOPETOUN EPZ LIMITED (Account number 34145128) who seemed to have been underbilled in the period 201905 however, they had a tariff change effected on 23/05/2019 from C3 to C1.

3.271 Other unexplained variances and the specific component affected are as summarised below:

i. PF- KES 6,211,005 affecting 365 accounts (Undercharged)

ii. FOREX - KES 625,359 affecting 2,260 accounts (Overcharged)

iii. REA - KES 254,285 affecting 690 accounts (Overcharged)

iv. VAT – KES 171,595,524 affecting 3,504 accounts (overcharged)

d) Debtors aging as at 30 April 2022

3.272 We performed[26] debt aging analysis for the period between 1 July 2020 and the period of 30 April 2022.The table below is a summary of the findings:

Debt Category	No of accounts (underpaid/unpaid amounts)	No of customers	No Of Active accounts	Debt Amount (Active Customers)	Debt Amount (Suspended Accounts)	Debt Amount (Terminated accounts)	Total Unpaid Amounts
0-30	3,415	2,851	2,587	3,777,582,536	20,755,210	-	3,798,337,746
30-60	2,193	1,623	1,609	3,205,949,654	1,767,214,317	-	4,973,163,971
60-90	333	280	272	1,182,088,056	145,125,114	-	1,327,213,170
90-120	209	182	173	997,642,278	627,046,922	41,713	1,624,730,914
120-150	160	143	122	833,734,536	56,585,095	-	890,319,631
150-180	126	114	96	712,757,380	8,803,451	42,782	721,603,614
180-360	145	131	97	700,612,213	1,247,389,152	1,691,669	1,949,693,033
360-720	85	82	50	281,006,564	8,344,025	97,436	289,448,025
720 or more	25	24	12	102,764,483	1,202,896,546	789,696	1,306,450,725

Table 56: Debt aging analysis between 1 July 2020 and 30 April 2022 Source: Our analysis of KPLC data

3.273 From the table above, we noted 750 customers with 676 accounts that have debts that exceeded 90 days. Among the accounts, 550 were active, meaning that they were consuming power.

[27] Appendix 24: Energy consumption threshold calculation

According to KPLC's policy, customers have to up to 14 days after which they should be disconnected. Where outstanding amounts are not settled within 90days upon disconnection, the account is to be terminated and the deposit used to offset the outstanding amounts.

3.274 The scenario as shown in Table 56 above implies nonadherence to the policy. The disconnection of supply and resolution of disconnection work orders as required by the policy was not being implemented effectively. Mr Wanyonyi explained that corporate accounts were exempted from the 14 day default disconnection and 90 day termination policy. He however did not provide the requisite policy to back the claim.

3.275 KPLC should also consider to integrating its Billing system with the debt aging system this will help to prevent the continuous billing of customers with debt exceeding 90 days.

e) Discrepancies between our independent power consumption measurements and the KPLC meters

3.276 As part of this review, we independently measured the consumption of 32 large power consumers for 7 days each over a two-month period ("logging"). We used data loggers ("loggers") that KPLC provided to us for this exercise.

3.277 The selection of the consumers was based on a risk-based analysis and our industry knowledge. The selected large power customers were spread across CI1 to CI5 tariffs and metered from 415V to 66KV.

3.278 We selected customers that exuded the following characteristics:

i. Customers whose consumption exceeded 30% of their previous 3-month average consumption. In this test we calculated a 3-month prior consumption and compared it to the following month consumption and if the current consumption increased by 30%, we flagged them for logging. A similar analysis was done for customers whose consumption decreased abruptly by more than 30% of their previous 3-month consumption.

ii. Customers in tariffs C1-C5 who's previous 3-month average consumption is consistently less than 15,000 units. Based on our analysis such customers ideally should be moved to a lower tariff as they enjoy discounted rates yet not meeting thresholds set by KPLC.

iii. Customers with frequent re-billings attached to their accounts. This is captured by filtering out accounts with negatives High-Rate and Low-Rate unit readings as well as negative total bills. iv. Customers whose power factor surcharge contributed to more than 30% of the total bill. We filtered out customers with extremely low power factor ratio calculated as (Active Power<KVA>/Apparent Power<KW>)

v. Customers with high total bill variations after comparing the bills KPLC had computed with our independent bill re-computation.

vi. Customers whose consumption spiked after installation of smart meters. We picked out samples of customers whose consumption spiked then normalized after a few months plus customers whose consumption increased without a drop.

3.279 The table below shows the distribution of the customers that we selected for independent consumption measurement by Voltage level, tariff, meter wiring and meter accuracy class

Voltage Level	Tariff	No of Customers	Meter Wiring		Metering Accuracy Class		
			3-phase 3-wire	3-phase 4-wire	0.2S	0.5S	1.0S
132 KV	CI5	1	0	1	1	0	0
66 KV	CI4	4	2	2	1	2	1
33 KV	CI3	4	1	3	3	0	1
11KV	CI2	16	11	5	5	2	9
415V	CI1	7	0	7	6	0	1
Total		**32**	**14**	**18**	**16**	**4**	**12**

Table 57: Voltage level, tariff, meter wiring and meter accuracy class Source: PwC

3.280 We summarize our observations as below: **e-1) Meter Measurement Comparison with Loggers**

3.281 Following our logging exercise, we noted a relatively high variance between the customer meter readings and the logger readings. More than 50% of the logged customers showed a variance of more than 1%. Further, 10% of the logged sites showed a variance above 3% which is higher than what KPLC has set as the limit for replacement of meters.

3.282 We have not established the basis for KPLC's 3% maximum allowable error because the KEBS standard on metering which is adopted from the IEC Standards is KS IEC standard 62053-21/22 where the allowable errors are based on the meter class and are as follows:

Meter Class	% Max Allowable Error
0.2S	+/- 0.4%
0.5S	+/- 1%
1.0S	+/- 1.5%

Table 58: KEBS metering standards (Allowable Meter Class Errors) From IEC 62053-21-2020 and IEC 62053-22-2020
Source: KEBS information

3.283 The table below show the distribution or % errors across the customers we logged

Voltage Level	Tariff	No of Customers	0-+/-1%	+/-1-+/-3%	Above +/-3%	Unclassified*
132 KV	CI5	1	1	0	0	0
66 KV	CI4	4	0	4	0	0
33 KV	CI3	4	0	4	0	0
11KV	CI2	17	7	5	4	1
415	CI1	6	5	1	0	0
Total		**32**	**13**	**14**	**4**	**1**

*Table 59: Variations between customer meter readings and the logger readings Source: IEC 62053-21-2020 and IEC 62053-22-2020 * Pole mounted meter that was inaccessible for our logging.*

3.284 The following table shows the meter measurements in comparison to the loggers. The negative values indicate where the loggers showed a higher consumption than the customer meter while the positive values are the vice-versa.

No.	Customer Name	Logger vs Customer Meter Difference	Metering Voltage
1	Mombasa Maize Millers Ltd	-9821.13%	11 KV
2	Kangaita Tea Factory Ltd	-81.41%	415 V
3	Malplast Industries Limited	-4.41%	11 KV
4	Consol Glass Kenya Limited	-3.62%	11 KV
5	James Finlay (K) Ltd	-3.09%	33 KV
6	Packaging Industries Limited	-2.91%	11KV
7	National Cement Company Limited	-2.21%	66 KV
8	Tarmal Wire Products	-2.09%	33 KV
9	Adix Shoes Ltd	-2.02%	11 KV
10	Keda kenya ceramics Co Ltd	-1.88%	33 KV
11	Accurate steel Ltd	-1.84%	66 KV
12	Grain Industries Ltd	-1.65%	33 KV
13	Halar Industries Limited	-1.55%	11 KV
14	Associated Battery Manufacturers Ltd	-1.40%	11 KV
15	Mabati Rolling Mills Ltd	-0.97%	132 KV
16	Greenhills Investments Limited	-0.95%	11KV
17	Ashut Plastics Limited	-0.82%	11KV
18	Songoiywo Holdings Limited	-0.66%	11 KV
19	Shoshona International Ltd	-0.55%	415V
20	Pember Flour Mills	-0.24%	66 KV
21	Galaxy Plastics Limited	-0.04%	415V
22	Polythene Industries Ltd	0.06%	11 KV

23	Associated Battery Manufacturers Ltd	0.24%	11 KV
24	Kenya Railways Corporation	0.28%	66 KV
25	Mombasa Maize millers Ltd	0.39%	415V
26	Kenya Builders Concrete Company	0.40%	415V
27	Thermopak Limited	0.61%	415V
28	Doshi & CO Hardware Limited	0.67%	11KV
29	Soma Associates	0.98%	11KV
30	Paras Industries Limited	1.06%	11KV
31	Metal crown limited	9.22%	11KV
32	Madhu Paper International Ltd	NA*	11KV

Table 60: Comparison between meter measurements and loggers

NA: The logging process did not complete successfully due to power outages*

3.285 According to the KS IEC 62053-21/22-2020 Metering standards more than 50% of the meters we logged have errors that are outside the acceptable standard and need further investigation or recalibration.

3.286 The notable -9,821.13% variance at Mombasa Maize Millers is attributed to a difference in PT ratios. The PT ratio set at the meter was 1/1 V, while the PT ratio in the C&I system was 11000/110V. The above resulted in a consumption reading on the meter that was less by a factor of 100. However, the customer billing was correct since the C&I system had the PT right ratio. Eng. Joseph Njoroge (KPLC) explained that the meter was likely not programmed by the lab before deployment and might not have been online when the correct ratios were set in the C&I system

3.287 The -81.41% variance at Kangaita Tea Factory was on the meter. The instantaneous meter readings of current and voltage were comparable to the logger but the consumption in kWh on the meter was significantly different. It is possible that the meter register could be slower than expected. KPLC needs to investigate this anomaly further.

3.288 The KPLC staff member in charge of the Kangaita Tea Factory was, Mr Samson Warui, acknowledged that the meter had not been inspected for over 6 months as the KPLC metering manual requires. It is important as stipulated in the KPLC metering manual that large customers are inspected, tested and any anomalies rectified to protect revenue.

3.289 For other customers that we logged and observed high variances as noted in the table above, we recommend that KPLC undertakes further investigations on them to establish the cause and take appropriate remedial actions.

3.290 Following our field visits, we also noted the ease of accessibility of meters to the customers. Examples of such sites include KEDA Kenya ceramics Co Ltd and Kangaita Tea Factory Ltd. KPLC should endeavour to restrict customer access to the meter while ensuring that KPLC staff have unhindered access to the meter without seeking permission from the customer. This hampers any inclination to tampering with the meter.

Qualification of logger measurements

3.291 In interpreting the above findings from the logging exercise, the below needs to be taken into consideration.

i. **Mode of logging**: The loggers provided to us by KPLC needed to be connected to the same CT and PT wires as the customer smart meters. This implies that:

   a) The logging was essentially a test of the accuracy of the customer meters.

   b) The logging would not be able to identify cases where: There is a bypass before the meter, the CTs and VTs have been interfered with or the signal from the CTs and VTs have been interfered with. These scenarios can only be caught by the use of High Voltage Clamp Meters on the primary conductors directly.

ii. **Verification *using a standard meter:*** Given the significant errors that we encountered in some of the sites that we logged, we sought to verify some of the errors using a portable

Energy Standard Meter ("ESM"). An ESM is a test equipment used for testing the accuracy of energy meters. The typical accuracy of this standard meter is 0.05% which is higher than the meter with the highest accuracy at 0.2%

The following are the results of the logger and standard meter tests done on the customers who registered a logger meter error of +/- 1.8% and above.

No	Customer Name	Logger vs Customer Meter Difference	ESM vs Customer Meter	
			Pulse rate Error	W register error
1	Accurate Steels	-1.84%	3.97%	4.36%
2	National Cement	-2.21%	0.42%	1.15%
3	Metal Crown	9.22%	0.16%	0.09%
4	Packaging Industries	-2.91%	0,13%	-0.17%

Table 61: Logger vs standard meter tests (customers with logger meter error of +/- 1.8% and above) Source: PwC

The above test did not sufficiently verify what the loggers had shown over the 7-day period. The standard meter test show that the meters were fairly accurate for National Cement, Metal Crown and Packaging Industries. Given that our logging exercise is essentially a meter test as described in i above, this likely indicates a problem with the loggers.

KPLC should further investigate the cases to determine the causes of the varied results between the loggers and the standard meter.

iii. **Communication of intent to log**: we note that in most cases, KPLC client relationship officers had to be informed of our intent to visit customer sites in advance for logistical purposes. There is a possibility that the customers would have been alerted in advance to clear any illegal connections before our arrival.

e-2) Meter Wiring

3.292 From our sample of 28 large power customer metered at 11KV and above, 19(68%)had 3-phase 3wire meters. This shows a preference to this type of meters among large power customers. A 3phase 3-wire connection assumes that equal current passes through the 3 phases. Only two phases are measured with the third phase being assumed as having similar current to the other two phases.

3.293 This kind of wiring is suitable where power loads are balanced on each phase e.g., where only 3-phase motors or 3-phase heaters exist and have equal current in each phase. A typical customer's premises will have different loads including single-phase loads like lighting, sockets, and other single loads that create an imbalance in the phases. As a result, the use of 3-phase 3-wire meters may lead to erroneous measurements where the loads in the three phases are not balanced

3.294 Among the set of power utilities (including Indian utilities with similar profile as KPLC like TSSPDCL, TPDDDL, BSES, Torrent Power) in our benchmarking exercise, we noted preference for 3 phase 4 wire HT Trivector Static energy meters. The meter deployed are suitable for measurement of active energy (kWh), reactive energy (kVArh) and apparent energy (kVAh) and power demands (kW, kVAr, kVA) with balanced and unbalanced loads over a power factor range from zero (lagging) through unity to zero (leading).

3.295 To enhance the accuracy of metering, 3phase 3 wire meters should be replaced with 3phase 4 wire meters especially for large power customers.

f) Prepaid Customers consuming units of low amounts.

3.296 We carried out an analysis of prepaid customers token purchases for the month of March 2022.

3.297 From our analysis, we noted a significant number of customers who appear to consistently purchase suspiciously low amount tokens. We noted 200,761 cases involving 52,596 unique mobile numbers where customers purchased units worth KES 1 in March 2022 for 48,819 unique meters.

3.298 We noted two particular cases as described below:

i. Mobile number +254721482094 purchased units worth KES 1, 1,018 times. According to Mr. Wanyonyi, when contacted, the customer explained that she owns a salon so she buys tokens strategically in small amounts, this she says is favorable to her economically. We found the explanation given unsatisfactory because the amount of units generated by KES 1 is barely enough to light a bulb for a minute let alone power the equipment at the salon. It is also tiresome to input the sixteen-digit combination one thousand times.

ii. Mobile number +254769038501 purchased units worth KES 1, 278 times. According to Eng. Wanyonyi, when contacted the customer explained that she buys tokens for her neighbors found the explanation unsatisfactory because not all consumers buy tokens worth KES 1.

3.299 Following our discussions with KPLC the following possible scenarios might explain the anomalies.

i) Fraudsters who pose to sell tokens at a subsidized price buy the KES 1 tokes then change the message to match what they pose to sell.

ii) A systems developer trying to automate token imputation in meters.

3.300 KPLC needs to look into the noted cases to determine whether there is more to the noted token purchase anomalies.

3.301 Further, the income gained by KPLC from such fractional purchases of power does not justify the resources utilized in the generation and transmission the units. KPLC should consider the setting a minimum purchase value for token purchases.

v) Industry analysis of power usage

3.302 We carried out a peer-to-peer energy consumption analysis for select industries to assess if there are large consumers whose consumption is not in line with their peers or is out of sync with the trends in their respective industries.

3.303 We focussed the analysis on the industries that are generally known to be large power consumers i.e. cement, steel and plastics. The depth of our analysis varied from industry to industry based on the availability of information e.g. production data, the installed capacity etc.

3.304 In the cement industry for instance, information regarding the annual production and installed capacity for the larger players is available in the public domain or in government registries which is not the case for the smaller cement players, steel, and plastics industries. This impacted the depth of our analysis in areas where data is not readily available.

3.305 We discuss our observations in the section below:

a. Cement industry analysis

3.306 We focussed the analysis on the five largest players going by the market share statistics from the Kenya National Bureau of Statistics ("KNBS"). The five are National Cement Company Limited, Mombasa Cement Limited, Bamburi Cement, Savannah Cement and East Africa Portland Cement ("EAP Cement").

3.307 We further narrowed down the analysis to a sample period of January – December 2020 where according to the KNBS, the annual cement production was about 6.5 MT. Based on this, and the market share statistics also from KNBS, we derived the annual sales in for the five cement companies.

3.308 We further carried out open sources of research on the average power consumption in producing a metric tonne of cement and clinker ("MT"). We used this average to derive the expected consumption by the five players which we compared to the actual usage based on the KPLC records. The outcome of this analysis is summarised in the table below:

i) Cement Production

Company	Market Share	Derived Sales (MT)	Gross kWh/MT	kWh/MT cement (30%)	Expected Consumption (kWh)
National Cement	33%	2,145,000	103	31	66,280,500
Mombasa Cement	23%	1,495,000	103	31	46,195,500

Bamburi Cement	23%	1,495,000	103	31	46,195,500
Savannah Cement	10%	650,000	103	31	20,085,000
EAP Cement	3%	195,000	103	31	6,025,500

Table 62: Cement production market share, expected vs actual consumption in producing a Metric Tonne of Cement Source: PwC **ii) Clinker Production**

Company	Estimated Clinker Production (MT)	Gross kWh/MT cement	kWh/MT Clinker (70%)	Expected Consumption (kWh)
National Cement	1,072,500	103	72	77,327,250
Mombasa Cement	747,500	103	72	53,894,750
Bamburi Cement	373,750	103	72	26,947,375

Table 63: Clinker Production analysis Source: PwC

iii) Cement and Clinker combined (kWh)

Company	Expected Consumption (Clinker)	Expected Consumption (Cement)	Total Expected (Consumption)	Actual Consumption	Variance
National Cement	77,327,250	66,280,500	143,607,750	70,767,033	-72,840,717
Mombasa Cement	53,894,750	46,195,500	100,090,250	178,495,920	78,405,670
Bamburi Cement	26,947,375	46,195,500	73,142,875	173,357,156	100,214,281
Savannah Cement		20,085,000	20,085,000	26,490,384	6,405,384
EAPC		6,025,500	6,025,500	35,665,947	29,640,447

Table 64: Cement and Clinker production Analysis Source: PwC

3.309 We obtained the estimated power consumption per MT of cement and clinker from the Africa average published by the International Energy Agency ("IEA"). We understand that, Savannah Cement and EAPC import all their clinker and hence the reason why their expected power consumption on clinker production is nil. Bamburi Cement imports 50% of its clinker while the rest in manufactured locally. Mombasa Cement and National Cement use their locally produced clinker. We further assumed cement is made up of 60% clinker which is the most common cement mixture in Kenya going by an article by Business Daily Africa.

3.310 As shown in the tables above, for all the cement companies that we analysed save for National Cement, the actual consumption was higher than the derived expected consumption. This could be attributable to factors such as production inefficiencies, power consumption inefficiencies, power usage for other operations other than the core production processes etc.

3.311 The consumption by National Cement however appears to be substantially lower than expected. National Cement is the largest cement manufacturer going by the marker share but it has the lowest power consumption. This corroborates our analysis and that by KPLC investigation that we have discussed in the preceding sections regarding unusual power consumption patterns by National Cement. KPLC should explore this further to establish the cause of this anomaly. **b. Steel industry analysis**

3.312 Unlike the cement industry, most of the steel companies are privately owned enterprises and do not publish their books of account to the public. Information regarding their production levels is therefore not readily available in the public domain. This limited the depth of analysis to overall consumption analysis based on the KPLC records where we made the following observations that are of interest.

i) Increase in power consumption following the ban of scrap metals

3.313 On 20 January 2022, the Government of Kenya imposed a ban on the exports and dealings in scrap metal. This had the effect of slowing down the operations by the steel companies since most of them use scrap metal as an input in their production processes. The expected impact of this was reduced power usage

3.314 Whereas power usage by most of the steel companies declined as expected in the period following the ban, our analysis showed that usage by some few large steel companies increased substantially. This is as shown in the table below:

Customer Name	Meter Number
Ltd Mills Prime Steel Meter number	040016110705
Doshi & Co Hardware Meter Number	040016111822
Prime Steel Ltd Meter Number	040016111938
Abyssinia Iron & Steel Ltd Meter Number	040016110732
M/S Corrugated Sheets Meter Number	040016110300

Table 65: Steel companies with increased power consumption after ban of scrap metals Source: PwC Analysis on Large Power InCMS billing data

3.315 KPLC should consider further investigations on these companies to establish what caused a power consumption increase at a time when their usage was expected to decline. It is also important to note that the ban of scrap metal was just before the commencement of our review. Our review was extensively reported in the media as a clamp-down on power theft. This may have triggered corrective measures by players who may have been manipulating power consumption. **ii) Inconsistencies in the power consumption by some steel companies**

3.316 Jumbo Steel Limited (Meter Number 040016113779) stood out by showing consumption anomalies with 11 negative billings or credits in November of 2019.

3.317 The explanation given by KPLC's Joseph Njoroge was that there was a mismatch between the transformer CTs and the meter programming. Due to this mismatch, the customer meter was recording inaccurate consumption reading and resulting to an overcharge of KES 3,196,422 over a period of 11 months. Therefore, KPLC had to compensate the customer hence the 11 negative complementary rebilling.

3.318 We further observed that in March 2021 KPLC changed the Jumbo Steel meter PT ratios from 1/1 V to the existing ratio of 33000/110 V and CT ratios from 500/5A to 400/1A. This led to an immediate increase in power consumption in the subsequent months. When compared year on year, year 2020 vs 2021, the Jumbo Steel power increased with over 303%.

3.319 KPLC records show that Jumbo Steel had made an application for load increase on Jan 2018 through load application letter reference No. A21202019010002, KPLC uprated their metering infrastructure in April 2020. It was expected that their consumption would go up following the commissioning of the uprate but it only went up in March 2021 KPLC changed their PT and CT ratios. It was not clear why KPLC did not change the PT and CT ratios at or before commissioning of the uprated infrastructure which is the expected practice.

3.320 Based on these observations, KPLC should investigate the sequence of event further with a view to establishing why the right procedure was not followed and to assess if Jumbo Steel consumption was appropriately billed in the period before their PT and CT ratios were rectified.

3.321 Endmor Steel Millers Ltd A/C No. 65088728 had an increase in consumption in October 2020. The same customer had a Change in August 2021 from 040016110710 to 040016112674.

3.322 The explanation given by Mr Felix Juma ("Mr Juma"), Internal Audit KPLC is that Endmor Steel Millers Ltd was uprated based on their load increase application Reference No. A21202017110001. A change in PT CT ratios was done after the meter change to match the customer's load. **c. Plastic Industry**

3.323 Galaxy Plastics A/C No. 46883496 had an increase in consumption in June 2020 and a meter change from 040016112587 to 040016116787. The meter change came after the increase in consumption.

3.324 According to Mr Wanyonyi, In Galaxy Plastics the initial meter installed had a Mismatch between CT programmed and actual. This meant that the customer was being underbilled. The new meter installed had correct ratios implemented. After the correction consumption increased. As a result, lost revenue recovery of KES. 3,646,510.84 was made.

3.325 King Plastics A/C No. 21132410 had a significant increase in consumption in May 2019. This customer had a 125% increase in consumption when compared with previous 3 months period. According to Mr Wanyonyi, the consumption goes down in 2017 following ban in plastics. Pick in consumption in 2019 majorly attributable to diversification of the customer in plastic product manufacturing.

vi) Conclusion

3.326 The work we did highlighted questionable losses and consumption anomalies by some large customers that could result to commercial losses. KPLC should investigate these cases further and broaden the scope beyond the sample that we reviewed. This will enable KPLC institute suitable interventions.

3.327 Going forward, it is important for KPLC to progress the ongoing exercise of breaking down the losses at the regional, counties and feeders' levels. This will require investment in areas such as metering where there are gaps. Breakdown losses to the counties and feeders' level will enable KPLC target the losses reduction initiatives to the areas with the most significant losses.

D. *Processes and practices assessment*

i) Introduction

3.328 We consulted with the relevant KPLC teams to understand the business issues, with a focus on processes, technologies, organization and facilities. This helped us understand KPLC processes as well as compare them to leading practices to identify gaps that may exist. We also reviewed the relevant regulations, policy documents and industry benchmarks to assess the gaps and identify improvement opportunities.

3.329 The opportunities for improvement that we have proposed are based on industry leading practices in power distribution utilities of similar profile (consumer mix, geographical area, energy sales) as KPLC.

3.330 We collected the best practices of process improvement for loss reduction adopted by various utilities in India, Bangladesh, Sri Lanka and the USA. The power distribution utilities selected are based on them either performing better that KPLC in terms of standard industry practices or having a similar consumer profile as KPLC. We looked at organizational, managerial, and technological aspects.

3.331 We tabulate below the profiles of power distribution utilities considered for benchmarking.

Utility	Country	Geographical area (Sq.km)	Total Consumers (m)	Distribution Loss – Technical and Commercial (FY 21/FY 22)
KPLC	Kenya	582,646	8.2	18.46%[28]
TPDDL	India	52,000	9.3	6.83%
TSSPDCL	India	510	1.8	19.91%
MSEDCL	India	307,713	27	13.09%
MPMKVVCL	India	96,069	4.9	27.6%
BRPL	India	750	10	7.28%
DGVCL	India	23,307	3.2	6.73%
Torrent	India	120	1.9	5.5%

[28] Distribution loss as of March 2022

AEML	India	400	2.1	7.37%
BPDB	Bangladesh	34,827	3.3	8.99%
LECO	Sri Lanka	3,000	0.6	-
PG&E	USA	70,000	5.5	-
Eastern Power Networks	UK	20,300	3.6	-

Table 66: Leading industry practices of power distribution utilities
Source: Secondary data

The PTOF Framework

3.332 The assessment of the processes at KPLC were based on the Process Technology Organisation Facility ("PTOF") Framework. The PTOF Framework entails the following:

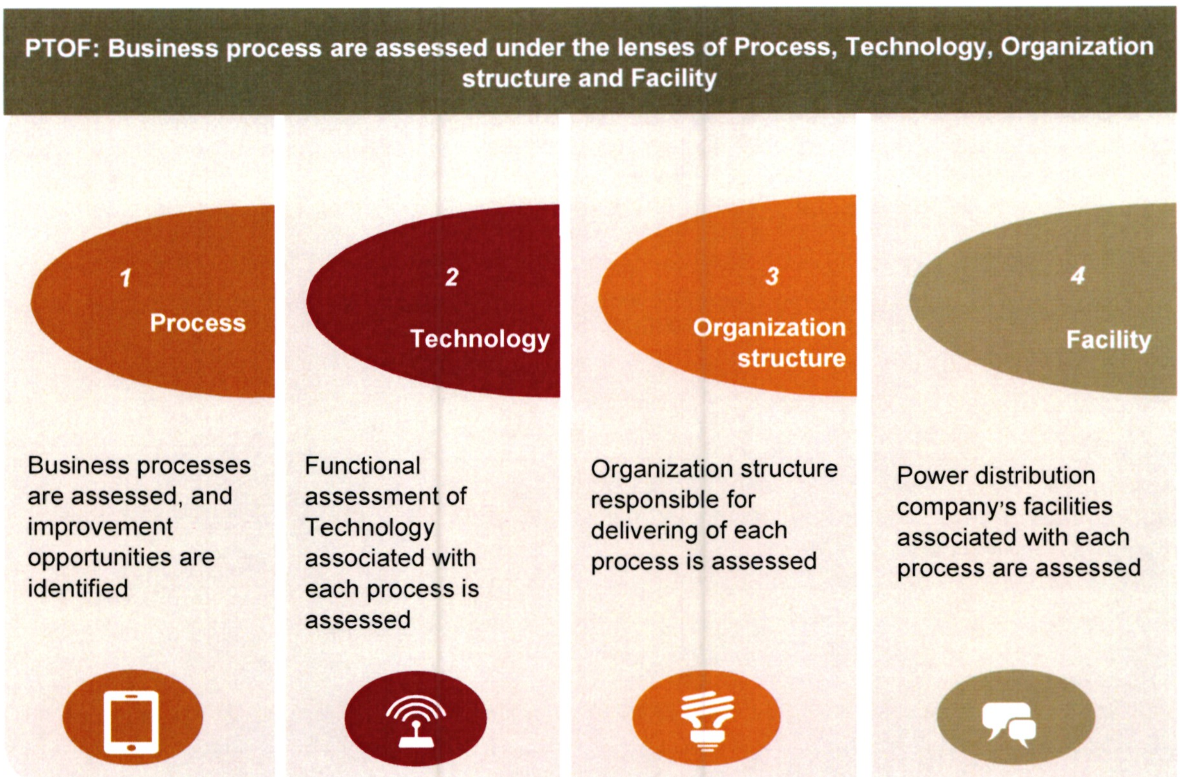

Figure 9: PTOF Framework

3.333 The following table provides a detailed description of each parameter:

Parameter		Topic
Process	• KPLC's business processes are assessed, and improvement opportunities are identified	• A process is the step or action that combines to produce a particular goal. • Processes cover the meter to cash in the lifecycle of KPLC's transactions with consumers in the retail supply of power.
Technology	• Functional assessment of technology associated with each process is assessed	• This covers the review of the tools used to implement the processes.
Organisation	• Organization structure responsible for delivering of each process is assessed	• This covers the governing elements of the processes, which include practices for monitoring, manpower, roles and responsibilities.
Facility	• KPLC's facilities associated with each process are assessed	• Refers to the infrastructure available at the KPLC's disposal for executing the processes. • This parameter highlights the internal capabilities and support required for leveraging the use of the technology assessed above

Table 67: Process Technology Organisation Facility ("PTOF") Framework
Source: Secondary information

Relevance of the study of Business/ Commercial processes of KPLC

3.334 The study of the Business/ Commercial processes was done due to its impact on crucial parameters of the Power distribution business, the impact on these parameters is described below:

ii) Detailed Process diagnostic, Opportunities and Action plan for \improvement

a) New connection and metering

a-1) Background

3.335 Managing new consumers involves the addition of new customers who start using the services of the power distribution company. Services refer to the connection with the electricity grid as well as other customer service-related facilities provided by the company. While it is important to continually acquire new consumers, a power distribution company must also track and bill the new consumers. This is especially important where new consumers consume power but are not regularised in the system.

3.336 The KPLC's 'New Connection Policy 2020' provides the latest customer application procedures, including service line applications, meter separation, applications with loads below and above 1,000 kVA, additional load applications etc. The policy stipulates the modes of application, the payment procedures and timelines, the documentation required etc.

3.337 The Kenya Power Customer Charter stipulates the connection timeliness at various voltage levels, timelines for allowable duration of interruption, voltage regulation, meter reading and billing complaints etc.

3.338 As per KPLC's metering manual, metering by Current Transformer (CT) is mandated for premises that have connected loads of demand between 70 kVA and 900 kVA. High Tension (HT) metering installations are mandated for loads of demand exceeding 900 kVA.

a-2) PTOF framework: Key observations – Gaps – Improvement opportunities

Sl	Parameter	Key observations	Key gaps	Improvement opportunities
1	**Process**			
1.1	Registration	• Applicants have the choice to either apply online or through KPLC's offices. • Application forms for new service connection are available at KPLC's commercial offices or from KPLC's website for online submission. • An application number is self-generated instantly during online application for future correspondence reference. • After the completion of registration of a new connection application, an SMS alert is sent to consumer with the reference number as part of acknowledgement process.	• Offline application and human intervention can lead to delay in the generation of the application number, without the ability of KPLC to track the delay due to inherent nature of lack of transparency of offline procedures • For offline application, KPLC staff still have to fill in system application forms in the KPLC InCMS ("Integrated Customer Management System") portal.	• KPLC can mandate compulsory registration of new service connections through the online mode, especially for connections above a threshold e.g., 50 kVA as well as industrial consumers. This would improve the ease of doing business in respect of the power sector in Kenya. • For the large power and high value consumer classes , KPLC can consider introducing an application charge for offline registrations at their county office, subject to regulatory approval. In addition to generating income for KPLC, the incentive mechanism will promote the use of online services among these categories of consumers.
1.2	Payment	• Applicants are not required to pay at the time of new service connection application. • Design estimate charges are collected after installation inspection by KPLC's engineers.	• Since applicants do not make any payments upfront, they are not incentivised to play their part in the process. • This leads to delays and/or noncompletion of the connection lifecycle due to delays by the applicant completing their internal installations.	• KPLC can develop a mechanism of charging for new service connection applicants upfront for part or whole of the applied load. The following mechanism can be adopted. - System generated primary demand notice based on normative charges per kW/KVA, for applications not requiring extension of network or network augmentation. Once the payment is realized and inspection is completed, meter can be installed subject to the completion of applicant's internal wiring. - For applications requiring network extension or augmentation, field inspection to determine the adequacy of the primary demand charges. In this case, demand may be charged based on actual material requirement. In case where the payment against the primary demand is found adequate, work order can be generated faster by avoiding the lead time to wait for the applicant's payment

Sl	Parameter	Key observations	Key gaps	Improvement opportunities
1.3	Communication and agreement	• At document verification stage, KPLC's county staff contact the customer through telephone calls where additional information/submissions are required. • A service contract is signed by the consumer after the submission of all documents but before actual meter connection	• This submission of information through in-person mode can lead to delays in the new connection processes.	• Since all new connection applications are eventually uploaded in the InCMS portal, an online link/SMS can be provided for additional information submission by the applicant at document verification stage. This will reduce document transmittal time and improve the process transparency. • As part of the agreement with consumers' KPLC should develop a no connection without a meter
				policy, where meters should be the smart meters or pre-payment meters. This policy should be communicated nationally to ensure there is no deviation either from the respective KPLC's department, the contractors engaged or the consumer/applicant.
1.4	Estimate	• Design approval is based on the cost estimate and subsequent approvals at the level of Design & Construction engineer, County Business Manager, Regional Manager, Manager Power Systems (at Corporate Office) • Wayleave approval includes the Right of Way (ROW) granted to KPLC to erect the network in the course of service delivery. Way leaves may be granted by individuals, the government or government institutions	• Wayleave approval is not part of design and is separately managed by wayleaves section	• Wayleave process can be initiated in parallel at the time of site verification for design.
1.5	Connection timelines	• As per the KPLC Customer charter the connection timeline is 28 days for non-HT consumers.	• As per data available for FY 2021-22, 56.5% of applications required more than 14 days for cost estimation and 46.6% of applications required more than 14 days for connection. • The above shows non-adherence to service charter timelines	• Process improvement by way of upfront normative estimate and real time monitoring of new connection application can be explored.
2	**Technology**			

2.1	Design	• The Design and construction team does design preparation using he FDB portal, which has a superimposed google map layer. • The Survey team is involved for estimates involving installation of lengthy lines.	• As per the Manager, Business Development of KPLC, the HT network is 98% updated in FDB. • However, there is no mapping of LT network. As per the information available, the NYS project will cover the digitisation of the remaining 166,623.84 km of low voltage lines	• KPLC can complete the one time exercise to map the LT network with GIS for end to end mapping and load flow calculations. Subsequently, KPLC can map incremental changes on a timely manner. There should be a defined policy to map any new infrastructure and network post completion of the NYS project
2.2	Communication	• Consumers are sent SMS alerts for the estimate amounts. A physical estimate copy is only sent to consumers who request for it	• No SMS/ digital communication with customer between estimate generation stage and the supply connection date. As per KPLC, consumers can only check the application status either at KPLC's offices or by using a USSD code.	• KPLC can consider a website/ mobile app platform for checking the status of new connections as well as other consumer requests. • Providing SMS alerts to applicants prior to the date of meter installation and connection, with information on the date and the requirements for connection with the grid. This will improve manpower utilisation by ensuring customers are

Sl	Parameter	Key observations	Key gaps	Improvement opportunities
				available hence avoiding delays from the consumer's end.
2.3	Transaction handling	• The InCMS portal handles consumer transactions related to new service application lifecycle, from registration to regularizing the consumers for billing	• InCMS does not have a dashboard or monitoring charter timelines and reports need to be extracted by KPLC staff from the portal	• An integrated dashboard for timeline monitoring and automatic escalation can be implemented for monitoring stages of consumer application in each county and region
3	**Organisation**			

Sl	Parameter	Key observations	Key gaps	Improvement opportunities
3.1	Monitoring	• The Kenya Power Customer Charter outlines the timelines for providing connections to new service applicants. • The charter timelines are published in the KPLC website • The timelines for the charter are monitored by the Commercial Sales and Service department for the respective counties.	• For applicants requiring HT supply, the connection timelines are not included as part of the Customer charter. • There is no real time tracking of charter parameters. • KPLC does not provide applicants with a separate Terms and conditions document at the time of application. From global practices, we observe that documents on terms and conditions are provided to applicants to serve as information as well as obligation to meet the specific network design and regulatory requirements.	• Attaching internal timelines over and above the charter will improve the accountability and governance associated with new service connection management • KPLC can develop the Terms and conditions as part of the Customer Charter to serve as a mandatory requirement on the part of the applicants.
3.2	Manpower	• Design engineers and designers are located at every county for design of network and estimates generation • Installation of smart meters is done by the Projects Team within Infrastructure Development Department.	• There are no separate design engineers for large power consumers	• KPLC should consider having separate design engineers for large power with internal timelines for expediating the lead time for large power connections due to their importance.
4	**Facility**			
4.1	Infrastructure	The KPLC metering Manual provides for the following : • Metering Location/Positions : Only one metering position is permitted within single tenancy premises. In multiple tenancy premises, a centralized communal meter position is the preferred. • Pole metering is recommended for supplies which are highly suspect and notorious in electricity theft	• As per the Metering Manual, the meter location should be as close as possible to an entrance to facilitate ease of access	• To ensure proper positioning of new meters installed, the Work Orders should enable photo verification post meter installation. KPLC can designate Quality engineers to check random samples of meters installed for new connections • Pole metering with armoured service cables and ariel bunched network can be implemented to reduce energy theft

4.2		• During our initial discussions with KPLC's staff, it emerged that in the Rural Electrification and Renewable Energy Corporation ("REREC") Scheme, approximately 27,000 customers have been connected without meters. • The problem is compounded by the unavailability of meters at KPLC for connection of consumers.	• Unmetered connections mainly for rural domestic customers. Unmetered consumers lead to inability to plan power purchase and projected revenue and subsidy	• Meters should be linked to the new service application at an initial stage. This can be done though modification of the existing new service connection process. Meter procurement and installation should be made mandatory for release of any connection. • Metering cost associated with the REREC scheme should be part of the CAPEX planning at the time of approval. • In case where consumers are unmetered, KPLC should install meters at the distribution transformer to account for the loss of the area vis-à-vis the supplying feeder

Table 68: PTOF framework: Key observations gaps improvement opportunities
Source: PwC analysis based on KPLC's information

a-3) Service connection timelines in KPLC

3.339 The connection timeliness as per the KPLC's Customer charter are as per the table below. Notably, there is no specific timeline defined for applications for connections at high voltage level, which would cover the large power consumers, SMEs and other high value consumers.

Sl	Activity	Days required for the service							
		7	14	21	28	35	42	49	56
KPLC									
1	**Requiring a meter only**								
1.1	Notification of payment	7							
1.2	Connection timeline*		10						
2	**Requiring low voltage extension (3-ph above 8 kVA)**								
2.1	Notification of payment		14						
2.2	Connection timeline*				28				
3	**Requiring low voltage extension (1-ph up to 8 kVA)**								
3.1	Notification of payment				28				
3.2	Connection timeline*						42		
4	**Requiring medium voltage extension and/or transformer**								
4.1	Notification of payment				28				
4.2	Connection timeline*								56
5	**Requiring connection at high voltage**								
5.1	Notification of payment	**Within the period agreed with the consumer**							
5.2	Connection timeline* * Connection timeline is subject to payment of applicable charges by the applicant								
Telangana State Southern Power Distribution Company Limited ("TSSPDCL")*									
1.1	Connection timeline (Release of connection from existing network)					30			
Tata Power Delhi Distribution Limited ("TPDDL")*									
1.1	Connection timeline (Where no network augmentation is required)	8							

Table 69: Connection timelines as per the KPLC's customer charter
Source: Secondary research

Inference: The best performing utilities are taking less time for effective new service connection.

*Note: The detailed connection timelines of TSSPDCL and TPDDL are given in Annexure.

a-4) Prepaid metering

Topic	Remarks
• Consumer Base	• Currently KPLC has over 5 million consumers on the prepaid metering system.
• Technology	• The Prepaid System is a Web Based system with the following two features : o Online system whereby the vendors and the users connect to the same database immediately. Tokens that have been generated are also visible immediately to all logged on users. Sales information from vendors is available in real time. o Modular i.e., a system divided into smaller parts (modules) that can be independently created and then used to drive multiple functionalities e.g. Point of Sale (PoS) , retail admin
• Interoperability	• KPLC has deployed the STS technology to ensure interoperability between different infrastructure from different manufactures.
• Security	• A token purchased by a customer only works on the meter that it was purchased for.

• Meter Management	• The Eclipse Customer Manager (ECM) or ITRON is the module that handles the administrative, customer related processes and the Meter Management processes. • All Prepaid Meters are introduced in INCMS and integrated to ITRON through a webservice.
• Payment	• 88% of prepaid vending is done through Mobile Vending

Table 70: Prepaid Metering Overview
Source: Information provided by KPLC

Topic	Observation	Opportunity/ Best practice
• Vendor level transaction with KPLC	• The vendor has to maintain a minimum float to enable consumer to purchase tokens through their services. The float is the balance that the vendor has with KPLC at any given point of time.	• KPLC does not have a system to ensure minimum float. It is suggested that KPLC can develop a mechanism to enforce all vendors to maintain a minimum float to enable consumers to avail services of any vendor at any point of time
• Meter reading	• Since the prepaid meters are capable of one way communication and KPLC does not carry out any meter reading of prepaid consumers, the meters are susceptible to fraud or bypass.	• We observe that other similar utilities who have standalone prepaid meters endeavour to read the meter readings of prepaid meters at least once in a defined period e.g., every three months
• Location of meters	• The meters and the Consumer Interface Unit (CIU) can either be collocated or separately located depending on the type of premises. However, for prepaid meters, the consumer only needs to have access to the CIU. Having access to the meter increases the chances of energy theft by bypassing the meter or tampering the metering circuit.	• As per the 2015 Tetra Tech report, the recommendation of two part prepayment meters with the metering unit on the pole and the customer user interface in the house will need to be rolled out to the slums and rural areas
• Energy accounting	• The units (kWh) in the tokens are supplied to the consumer based on the amount purchased. Since KPLC does not read the prepaid meters, it is understood that the units sold via any token is consumed in the same month. This energy is used for computation of energy sales of prepaid consumers.	• The consumer may replenish the units over any number of months against the tokens purchased in any month. This can lead to erroneous computation of actual energy consumed by prepaid consumers in any particular month
• Meter balance	• The existing prepaid meters do not have any credit period. Once the balance is replenished, the power supply is disconnected. In case the consumer is unable to recharge at that point of time, there are chances of energy pilferage by bypassing the meters	• We observe that the prepaid meters deployed by power utilities have provision like alarm on low balance, credit period, etc to enable the consumer with adequate time to execute a recharge. The amount consumers during credit period is deducted at the time of the next recharge, which helps to reduce their susceptibility to bypass the meters as an intermediate solution.
• Analytics	• KPLC typically deploys two analysis for detection of anomaly viz., prepaid consumers who have never vended and consumers who have not vender for a consecutive period of 3-4 months.	• KPLC can deploy analytical tools which will help to bring out cases of potential theft by applying criteria based analytics and by comparing the energy consumption pattern of the consumers.

Table 71: Key observations, gaps, improvement opportunities
Source: PwC analysis based on KPLC's information

a-5) Benchmarking exercise

Comparison of industry practices related to Metering types and New service connection avenues

Parameters	KPLC	TPDDL	MPMKVVCL	TSSPDCL	Torrent Power AEML	MSEDCL	BRPL
New Service Connection- Online application process (Web based)	●	●	●	●	● ●	●	●
New Service Connection- Online application process (Web based)- Online documents upload feature	●	●	●	●	● ●	●	●

Predetermined charges for estimation without inspection		•						•
Separate department for High value connection management	•	•	•	•	•	•	•	•
Smart Metering	•	•	•	•	•	•	•	•
AMR metering	•	•	•		•	•	•	•
Pre-paid metering	•	•		•				
Infrared/ Bluetooth based meter		•					•	
100% Consumer metering in urban areas	*	•	•	•	•	•	•	•

Table 72: Metering types and new service connection avenues industry practices

** covers large power consumers*

** data unverified*

Source :Secondary research

Service Registration process- Industry practices

Utility	Country	- Practice
KPLC	Kenya	- Online (Website) and offline (commercial offices) options available - No Registration charges
TSSPDCL	India	- Mandatory online registration of new service applications with OTP based validation. - Uploading documents (such as material bills, work completion reports, approval, and etc. as relevant to that particular category) through an online portal - Registration charges are paid by the applicant upfront
Tata Power	India	- Online (Website, Mobile application) + Offline application - Registration charges applicable
MPMKVVCL	India	- Consumer can apply for LT/HT NSC via Urjas portal or Urjas mobile application - Registration fee can be paid online
BRPL	India	- New Connection request can be raised through different mediums as follows: ○ Call Center 19123 (24x7 Toll Free Helpline) ○ Division Office ○ Website ○ MobileApp
MSEDCL	India	- Applications can be done through the website, app or phone - Mobile app captures geocoordinates for a new connection - Approval for a new connection is done after the payment of fees by the consumer.
BPDP	Bangladesh	- After receiving a confirmation SMS, applicants must pay the application fee via bank draft or through online banking.
LECO	Sri Lanka	- Applicant has to hand over the duly filled application form along with the supportive documents to the closest Consumer Service Centre (CSC) or submit the application online. - No Application fees for new service Connections.
PG&E	USA	- Application can be done online (PG&E Connect) or download and print service applications forms. - Assistance on the application process from New Construction Service Center (NCSC) which is a team of employees dedicated to handling requests for new or upgraded utility service connections - Once the completed application is received, a PG&E representative (job owner), will contact the consumer within five business days

Table 73: Service registration process industry practices Source: Secondary research

Estimate and release process- Industry practices

Utility	Country	Practice
KPLC	Kenya	- Charged after inspection and preparation of estimate, based on actual estimate
TSSPDCL	India	- Prepared based on actual infrastructure requirement after inspection. Charges are communicated through SMS/ website - In case network augmentation is required to be executed by TSSPDCL, development charges are payable for new services. This is in lieu of the transformer capacity charges
Tata Power	India	- For LT supply up to 200kW/215kVA: Applicants are charged on the normative basis as per the applied load - Others charges as per actual infrastructure requirement after inspection
BRPL	India	- On-the-spot demand note generation on Digi Seva Kendra, a single window channel for all services - Normative Service line and Development (SLD) charges payable by the applicant for taking new electricity connection at LT supply for the connections upto 200kW/215kW
MSEDCL	India	- Consumers are updated about their application through SMS during the various process such as technical approval release of meter and release of connection.
LECO	Sri Lanka	- After estimate is prepared and approved, the Customer Service Center will issue a voucher for payments. Payments can be made at the Peoples Bank or POS counters at the Electricity Board. - Any payments including Bill payments can be made easily at the counters opened at the respective Area Engineer's Office.
Eastern Power Networks	UK	- Enquiry and application: The customer gets a budget estimate or a formal quotation either online or through a hard copy (which is sent to the customer) - Once the project has been designed, EPN will email the consumer an offer or send it by post if required. o If the consumer wishes to accept the offer, they sign and return an attached acceptance form and make the payment for the selected option.
Utility	Country	Practice
		- A field engineer is allocated, and Metering Point Administration Number (MPAN) assigned
PG&E	USA	- Upon receiving all payments, PG&E schedules the project for construction. - After the completion of construction activities, applicants can call PG&E's offices to schedule an appointment for meter installation.

Table 74: Estimate and release process industry practices Source: Secondary research

Metering- Industry practices

Utility	Country	Practice
KPLC	Kenya	- Prepaid Meters - Post-paid Meters - smart meters (AMI) – GPRS, PLC
TSSPDCL	India	- Prepaid Meters - Post-paid Meters – Infrared (IRDA) based - smart meters (AMI) – GPRS - Ensuring capacitors (for improving power factor) at the time of release of new service connection
Tata Power	India	- Predominantly smart meters - Separate team for Meter Management (stores to installation) - Permanent connections are to be encouraged. - Metering camps organized where fast track New Service connection and meterization can be done on fast track basis
BRPL	India	- Prepaid Meters - Post-paid Meters - smart meters (AMI) - GPRS
MSEDCL	India	- AMR for High Tension (HT) consumers - RF meters for Low Tension (LT)

BRDP	Bangladesh	- Installed 1.5 million prepaid meters and currently runs three different prepayment metering systems named Unified Prepayment Metering System, STS Prepaid System and Smart Metering System. - For Prepaid metering system, consumes can avail TOU tariff rates and slab facility if they have a compatible prepayment meter with 1% rebate on energy charge as per existing tariff order.
LECO	Sri Lanka	- Single phase and three phase electronic meters and electromechanical meters - Time of use facility - smart meters

Table 75: Metering industry practices
Source: Secondary research

a-6) Action plan for improvement in business process

3.340 We have developed an Action plan for improvement in Business process as below and segregated into Short term (0 – 6 months), Medium term (612 months) and Long term (More than 12 months).

Legend

NC	C	P	T	O	ST	MT	LT
Non capex/ Low capex	Capex	Process	Technology	Organization	Short term	Medium term	Long term

Name of activity	-	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
Normative charges applied during the time of application for connections, especially for high value applications	-	Develop a mechanism for system generated primary estimate amount based on normative charges, instead of charging after completion of network design	•			•		•	•		
Metering survey and SoP	-	Implement a meter tracking mechanism to track meters from store issue, through installation up to scraping through existing ERP	•	•				•	•		Prioritizing high loss feeders for realising benefit of metering survey and meter tracking, which will lead to accurate location of meters associated with each consumer account
	-	Develop SoP for survey of existing metering details and condition during consumer indexing	•				•	•			
Metering of unmetered consumers e.g. consumers under the REREC scheme	- -	Meters should be linked to the new service application at an initial stage. This can be done though modification of the existing new service connection process. Meter procurement and installation should be made mandatory for release of any connection. Metering cost associated with the REREC scheme should be part of the CAPEX planning at the time of approval.			•	•		•		•	
Distribution transformer (DTR)	-	Monitoring of input of sample DTRs on 15 days/ monthly basis to identify theft and need for new connection. This can be done by utilising existing operations staff and use of equipment like tong testers.			•	•		•		•	Reduction of unmetered energy

LT consumers (ordinary accounts)	-	Replacement of existing meters with Infrared /Bluetooth meters and group meters for high			•	•		•	•	•	

Name of activity	-	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
		loss areas/ bulk unmetered areas , where communication network is not established									
	-	Implement Infrared /Bluetooth meters and group meters for high loss areas/ bulk unmetered areas, where communication network is not established			•	•		•	•	•	Data analytics for load, consumption and tamper monitoring
	-	Replacement of stop/ defective meters in urban and semi-urban feeders				•	•				
Validation of consumer meter installation	-	Ensure quality work related to meter installation as per prescribed standards, photograph of new installed meter to be uploaded in KPLC's app and to be verified by competent authority	•				•	•	•	•	Ensure proper wiring connections and installation of meter
Online registration of New Service Connection ("NSC") mandating all documents with payment for large power and high value consumer classes	-	Online registration with load calculator and payment mechanism at the time of submission of NSC application	•	•				•	•		Decrease in timeline for NSC and increase customer satisfaction
SMS based information related to NSC procedures	-	SMS information related to approval of application, appointment of line staff for survey and installation of meter	•	•					•		SMS information related to various stages of NSC increase customer satisfaction and authentication related to NSC process.
Mandatory meter installation with verification process	-	No connection to be given without meter installed and verification to be done by taking photograph of the installation	•	•				•			Ensures meter is installed properly as per standards before release of NSC.
GIS based mapping of LV network	-	GIS based mapping of LV network to be completed and process for incremental updating of network changes post the completion of the NYS project			•	•			•		Monitoring of LV network
Integrated Dashboard for monitoring of progress of NSC	-	Development of a dashboard for monitoring the progress of NSC and their update in billing database.		•			•		•		Monitoring of NSC progress and corrective action by the management

Sample and ad-hoc quality check of meters installed	-	Quality check of meters installed to be done by competent authority in terms of meter, incoming and outgoing cables.	•	•				•		•	Ensures meter is installed properly as per standards before release of NSC

Table 76: Action plan for improvement in business process

Short term (0 – 6 months), Medium term (6-12 months) and Long term (>12 months).

b) Meter reading and Billing

a-1) Background

3.341 Meter reading and billing are critical processes in an energy utility's business operation. As new meters and devices are introduced into KPLC's distribution network, they need to be taken out of inventory, provisioned, and tracked as assets.

3.342 The business processes in this area include meter testing, whether routine or on-demand, meter exchange and meter retirement when meters reach the end of their lifecycle.

3.343 The billing process covers several areas including

i. Supporting the billing of KPLC's unique consumers
ii. Generating and distributing bills
iii. Setting up and monitoring budget billing
iv. The management of billing corrections and adjustments.

a-2) Process map

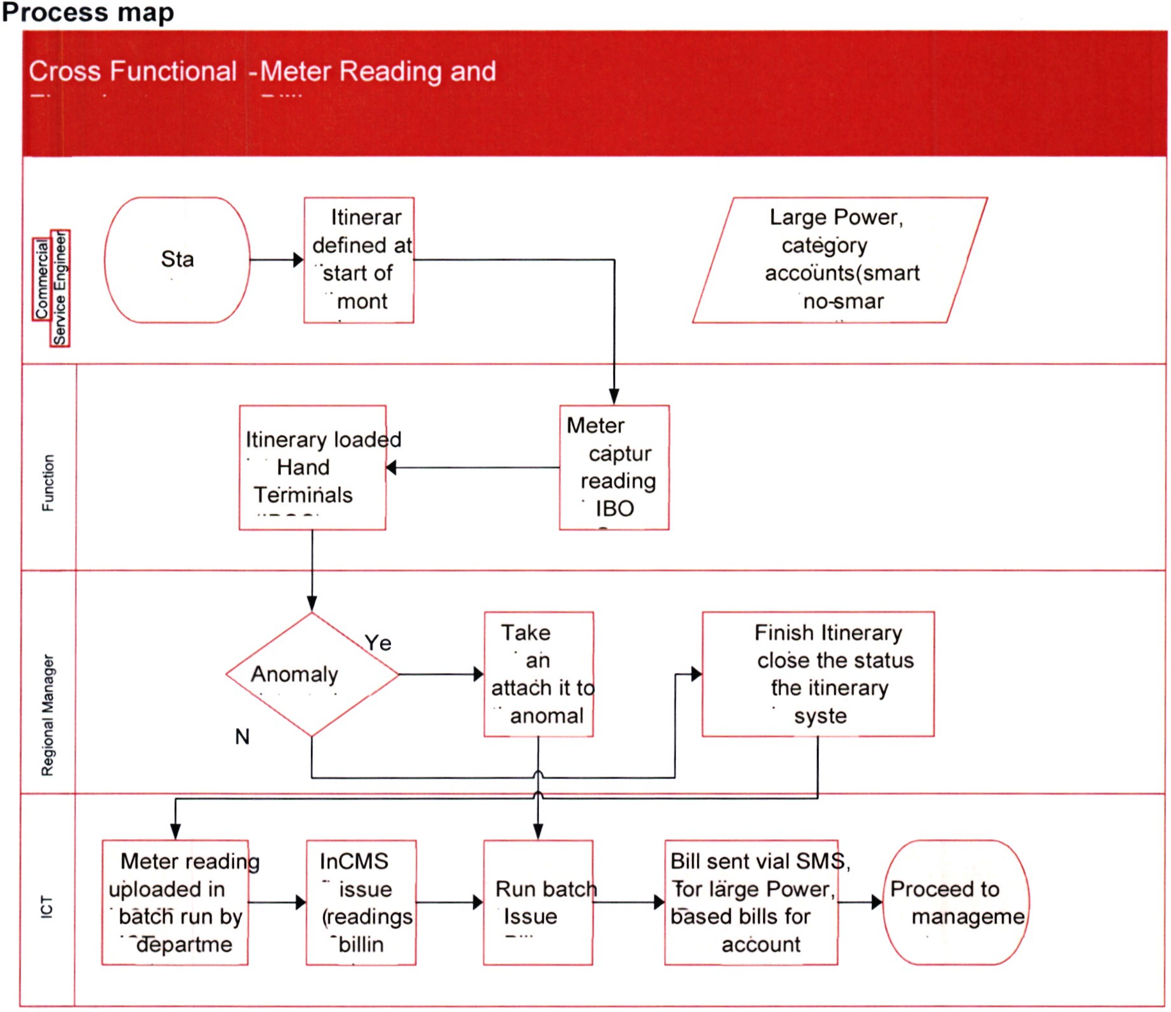

Figure 10: Meter reading and billing flowchart
Source: KPLC

a-3) **PTOF framework: Key** observations – Gaps – Improvement opportunities

Sl	Parameter	Key observations	Key gaps	Improvement opportunities and benefit
1	**Process**			
1.1	Meter reading calendar	• Meter reading is done based on the allocation of consumers in Itineraries ("ITINS"). The meter reading itinerary is defined at the start of the calendar month. • Itineraries are defined based on area e.g., distribution transformers, consumer population in the area etc. At present, there are 18,324 Itineraries for 2 million postpaid consumers (~ 109 consumers per itinerary). loaded into InCMS. • As per the ISO manual, the meter reading supervisors should receive extracted ITINS as per the meter reading calendar and confirm correctness within a day. • If the ITINS are not correct, the supervisors should request date control (central office) for re- extraction within a day. If the ITINS are correct, the supervisors should plan and assign to Meter Readers within two days.	• We understand that a good number of consumers are not correctly mapped in KPLC systems. Since an itinerary is defined based on existing database of consumers mapped in a particular geographical area, incorrect mapping of consumers can lead to cases of non-read meters • The adherence (KPI that identifies the compliance with the meter reading calendar) is 71.6% to 84.4% for FY 2020/21. This is on the lower side.	• Mapping of consumers to KPLC's network infrastructure is already in progress as part of KPLC's project in coordination with the National Youth Service (NYS). Based on the finalized data post the NYS project, KPLC can further assess the meter reading itineraries to improve meter reading adherence, which is below 85% for FY 2020/21 • A vehicle monitoring system can be explored for on-line route tracking and monitoring the performance of field staff through GPS.
1.2	Prepaid meters	• Prepaid consumer purchase tokens which they feed into their meters through a CIU unit. • KPLC does not undertake meter reading for prepaid meters. • Since most prepaid consumers buy tokens for short term use, it is assumed that the units bought within a particular month are consumed in that month.	• Due to the lack of periodic inspections, malpractices such as meter bypasses go unnoticed leading to power pilferage.	• Carrying out physical verifications of meter readings on sample basis based on analytics of consumption pattern to detect malpractices like meter bypasses to be done. For e.g. a strategy can be to have each prepaid meter read by the meter reader once every quarter/ half-year/year
1.3	Meter reading of Large Power consumers	• Meter reading for Large Power consumers is done at the end of the month. For large power consumers, the meter reading is typically completed in 3 days. For large power consumers with non-communicating meters, billing starts by 1st and end by 2nd or 3rd of the month • AMR and smart meters are able to freeze end of month readings for reading.	• Meter reading for large power consumers with non-communicable meters are done by Handheld units, where meter reading is entered manually and transmitted to the billing system through GPRS. • About 20% of the large consumers have AMR meters which have to be read manually as their automatic meter reading system became obsolete	• Large power consumers with noncommunicating meters, meter reading should be done using Meter Reading Instruments (MRI), which are accurate and eliminate human error in recording the meter readings

1.4	Exceptions	• Meter reading is not done in case of exception cases like lack of access. In these cases, meter reading is estimated based on historical consumption • Meter readers have to retake the readings for exceptions flagged by ICT. If the case is not resolved, such cases are sent for billing based on estimation	• Historical consumption for the previous period does not factor in seasonality of consumption. For e.g., consumption of the immediately preceding months may not reflect any surge in consumption that typically happens during the particular months of the year.	• Historical consumption can be defined as the maximum of previous 3 or 6 months or the same month of the previous year while taking into consideration any general increase in consumption. This will eliminate the seasonality effect of the historical

Sl	Parameter	Key observations	Key gaps	Improvement opportunities and benefit
			• The estimated bills cover around 14.5% of postpaid ordinary bills. On average, in FY 2021/22, 130K bills were issued based on estimation basis every month	assumption and ensure close to actual energy consumption recording.
1.5	Billing procedures	• Meter readings are uploaded to InCMS and batch run by the ICT department for billing. • For domestic and SME consumers, bills are sent via SMS. Customers are notified the bill amount and due date through SMS. Consumers can also check the bill in KPLC mobile app. • For Prepaid consumers, no separate billing is done. The token amount is considered as the consumption. Prepaid consumers purchase tokens through self-service USSD. • Physical bill distribution is done for corporate accounts. Liaison officer confirms the bill receipt. • Billing for smart meters is not done through Meter Data Management System (MDMS). Data from Head End System (HES) is transmitted to MDMS to InCMS for billing. AMI system does not have built in billing module	• Re-billings account for up to 0.9% of meter readings from July 2021 to February 2022. This indicates discrepancies in the initially recorded readings.	• Sending of SMSs to consumers prior to the meter reading dates can be explored to ensure availability of consumers at the time of meter reading. • Additionally, SMS of consumption recorded prior to billing the consumer can be explored, to ensure preemptive discrepancy settlement.
1.6	smart meter billing	• The Validation, Editing, and Estimation (VEE) of the MDM is deployed for generation of exceptional reports	• VEE is not deployed prior to the generation of electricity bills of postpaid consumers. This can lead to generation of erroneous bills, which have to be pass through rectification cycle and lead to blockage of KPLC's working capital	• VEE prior to generation of bill can flag any anomaly prior to billing and reduce billing error.
2	**Technology**			

SI	Parameter	Key observations	Key gaps	Improvement opportunities and benefit
2.1	Technology	• KPLC has deployed Hand held terminals i.e. IBOS, which are electronic notepads with in-built application for meter reading. Reading starts when supervisor assigns itineraries to the readers and ends when the reader uploads the itineraries with readings. IBOS can download and upload multiple ITINS at the same time. • The main function of IBOS is for the reader to key in readings of the meters/itineraries assigned to the reader. The reader can display the geolocation of all meters and ITINS that is currently assigned • The meter reading achieved is tracked by KPLC by way of a "Coverage Report ", which identifies the coverage of the meter readings in the itineraries.	• As per the Meter Reading Manual, if the coverage is less than 98% for a day, the meter reading supervisor returns the IBOS to the Meter Reader for follow-up within a day. Coverage report are also developed based on the meter reading data at the end of the meter reading cycle. However, from the data received, we note that the coverage at the company level ranges between 91.2% to 94% between July 2021 to Feb 2022, which is below the threshold.	• For areas where the coverage is less, KPLC can explore Spot Billing to ensure that consumers are receiving the monthly bills at the time of bill generation. This can be done by analysis of the coverage report on an ongoing basis
2.2	Reading methods	• The Meter Reading Supervisor loads ITINS in the various Handheld terminals (IBOS) and issues to the Meter Readers according to the work instruction for Meter Reading • The Meter Reader signs for the Handheld terminals in a job allocation register and goes to site to read as per the meter reading work instruction within a day or two days. • Photo reading is only done for exception cases in the handheld terminals. All meter readings are submitted real time. • Consumers who want to submit self-reading register with KPLC in advance. These consumers send readings through SMS/USSD code. Meter reading is directly loaded into the billing system.	• Approximately 150K consumers are registered for self-reading as of April 2022, which is 2% of KPLC's postpaid consumer base. We note that the readings are send through SMS hence there is no method to verify the authenticity of the readings e.g a photo-based method to verify the authenticity of the meter reading sent by the consumer through SMS	• Photo provision should be enabled for self-reading. • Self-meter reading through "Submit Your Meter Reading" can be provided through - Chatbot - KPLC mobile app - Third-party apps .Standard Cyber security procedures should be taken into account..
3	**Organisation**			
3.1	Manpower and Responsibilities	• At present, KPLC has employed around 800 Meter Readers. These are in house staff of KPLC • Meter Reading Supervisors are responsible for the reading process. The Commercial Service Engineer has the overall responsibility for implementation and maintenance of the procedure. • For the FY 2020/21, there were 7/47 counties where meter reading coverage was less than 90%, viz, - Migori, Kiambu, Kericho, Makueni, Garissa, Narok and Wajir.	• Given the postpaid consumer base of KPLC, meter readers responsible for reading of postpaid meters. This means each meter reader covers on an average 2500 consumers per month, along with verification required based on exceptions flagged. This is on the higher side compared to other discoms and the quality of meter reading can be hampered	• In areas where the meter reading coverage is insufficient, additional staff can be deployed so as to improve billing efficiency. • Alternate meterization for high loss areas/ bulk unmetered areas e.g., single point supply from Distribution Transformers ("DTR") where the incumbent developer would be responsible for meter reading, billing and collection

3.2	Exception management	• KPLC has established a Meter Reading Manual based on ISO 9001:2008 QMS. • On completion of reading the meters in the hand held terminals, the meter readers have to bring back the terminals with readings inserted, and then record property anomalies in the anomalies register	• As per the meter reading process manual, if the coverage for a month is less than 98%, the supervisor returns the hand held terminal to the meter reader for follow-up within a day. The meter reader re-visits unread cases within a day. If photo billing is made compulsory in meter reading process, such repetitive visits by meter readers can be avoided.	• Photo billing can help to reduce the number of revisits by meter readers.
3.3	Reporting and monitoring of meter reading	• The commercial sales and service tracks the meter reading using; - Quality reports (Exception report) - Reports that identify a number of issues with meter readings. - Adherence to the meter reading calendar report - Report that identifies the compliance with the plan.	• For FY 2021/22 (upto Feb 2022), the consolidated adherence is 78.7% and the rebilling is 0.8% of the total meters reading.	• To ensure better adherence and quality, a mobile app for field force management can be developed and/or integrated with the existing Work order management system for tracking the coverage on a daily basis during the meter reading calendar • Photo based billing provision can be enabled for all customer to reduce the number of rebilling cases.
Sl	**Parameter**	**Key observations**	**Key gaps**	**Improvement opportunities and benefit**
3.4	Revenue Collection	• The KPIs tracked for collection include - Collection ratio: Measures the billing of the previous month vs collections realized - Overdue debt reduction ratio: Tracks the month's Current overdue debt with the Previous overdue debt - Payment response ratio: Tracks the Non-zero bills vs the number of customers paid - Disconnection Work Order resolution ratio: Tracks the Work order resolutions	• There is no real time dashboard for tracking of KPIs for daily revenue protection activity	• KPLC should consider introducing additional KPIs with a real time dashboard for flagging of issues for tracking billing and collections as set out under table on recommendations on additional KPIs
4	**Facility**			
4.1	Scheduling	• The calendar is defined for every zone (454 zones). Meter readings in the calendar are typically completed within 20 days.	• There is no SLA / incentive for meter reading achievement or performance	• KPLC can develop SLAs and incentivise meter readers for achieving the KPIs

Table 77: PTOF framework: Key observations, gaps and improvement opportunities
Source: PwC analysis based on KPLC's information

a-4) Benchmarking exercise

Comparison of industry practices

Parameters	KPLC	TPDDL	MPMKVVCL	TSSPDCL	Torrent Power	AEML	MSEDCL	BRPL
Meter reading using the following technologies								
AMR communication		▯	▯		▯	▯	▯	▯
Spot billing- Hand held terminal		▯	▯	▯				
Meter reading activity								
Online tracking mechanism of Meter readers		▯		▯			▯	
Billing and Bill distribution								
Mobile SMS based bill distribution	▯	▯	▯	▯	▯	▯		▯
E-mail based bill distribution	▯		▯	▯				▯
Mobile app-based bill view	▯	▯	▯	▯	▯	▯	▯	▯
Chatbot			▯		▯	▯	▯	▯

Table 78: Industrial practices comparison
Source: Secondary research

Meter reading

Utility	Country	Industry Practice
KPLC	Kenya	- Meter reading through handheld terminals - Meter reading through AMI
TSSPDCL	India	- Meter reading GPRS enabled spot billing machines
Tata Power	India	- smart meter Reading Device based on android technology - In photo based meter reading, meter readers take photos of meter reading and submit to office, following which validation and billing is done. - RF based meter reading is conducted for LT Commercial & Industrial consumers for specific areas. IRDA based meter reading is also conducted for some LT Commercial & Industrial consumers.
BRPL	India	- GPRS in Meter Reading data uploading directly from field (“PDS”) to the Central Server - Key Consumer Categories (high value consumers) : AMR & CMRI - Introduced capturing the GPS coordinates during the meter reading at field

MSEDCL	India	- Meter reading for HT consumers and for consumers with connected load of 20kW and above done through AMR/ MRI - Rural LV : Reading using IR handheld terminal ("HHT") from a distance of 1-2 meters - Urban LV : Reading using RF handheld terminal ("HHT") and using RF canopy - Non communicating meters : Meter Reading App , where readings can be stored offline and uploaded when connectivity Is established - Scheduled date for meter reading sent to the consumer via SMS - Meter reading notification giving consumption send through an SMS to a consumer immediately after meter reading - Consumer uploads the self-reading and the photo through the consumer app

Table 79: Meter reading Industry practices
Source: Secondary research

Bill generation

Name of the Utility		Industry Practice
KPLC	Kenya	- Bills generated for post-paid consumers after validation
TSSPDCL	India	- Instantly generated through Integrated Spot Billing Machines. The ISBM are used as data logger for storing, retrieving and printing data.
Tata Power	India	- In spot billing, after meter reading, bill is generated and submitted to consumers at spot. - In manual meter reading/photo billing process, meter readers take meter reading in a diary and submit it to office. After validation bill is generated and emailed to consumers.
Adani Power	India	- After validation of meter reading, bill printing is done through outsourced agencies.
BSES	India	- Deploys multiple agencies for Meter Reading, Bill Distribution and Bill printing
MSEDCL	India	- Monthly bill generated and SMS alert sent to consumer, printed bill copy sent to consumer - Bill details updated on the Mobile App and the website - Payment reminders SMS sent to consumer Telephone calls are made to selected consumers to pay bills
DGVCL	India	- Monthly / bi-monthly spot billing system using GPRS based PDA (Personal Digital Assistant)

Table 80: Bill generation industry practices
Source: Secondary research

a-5) Action plan for improvement in Business process

3.344 We have developed an Action plan for improvement in Business process as below and segregated into Short term (0 – 6 months), Medium term (612 months) and Long term (More than 12 months).

Legend

NC	C	P	T	O	ST	MT	LT
Non capex/ Low capex	Capex	Process	Technology	Organization	Short term	Medium term	Long term

Name of activity	-	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit

Self-meter reading and SoP for photo based meter reading	- Self-meter reading to be encouraged for areas where no. of consumers per meter reader is high - Photograph of meter reading to be checked on regular basis	•				•	•			Monitoring sales impacting Commercial loss
Hand held terminal / Mobile app based meter readings with photo capturing feature or MRI based reading of LT consumers	- Monthly review of consumption recording to avoid meter reading on estimates and subsequent assessed billing - Maximum Demand verification of commercial, LV industrial and high load domestic category			•	•		•			Sales accounting and Commercial monitoring
Billing and follow up calls for cash collection	- Bill correction Monthly Information System cases to be monitored - Follow up calls/ WhatsApp based calls to consumers	•	•				•			Targeting consumers for revenue collection
Name of activity	**- Activity description**	**NC**	**ST**	**C**	**LT**	**MT**	**P**	**T**	**O**	**Impact/ Benefit**
Mapping of new consumers to KPLC's network infrastructure and billing database	- Consumer indexing to be done for commercial monitoring, can be done with existing meter readers	•				•	•			Feeder based monitoring is important for monitoring.
Vehicle monitoring system for online route tracking and monitoring through GPS	- Mobility to be taken into consideration for tracking of meter readers route			•	•			•		Tracking of meter reader route is important for monitoring.
Physical verifications on sample basis based on analytics of consumption pattern to detect malpractices like meter bypasses	- Strong past consumption monitoring before generation of bill e.g. inclusion of KPIs that compare Y-o-Y and M-o-M consumption	•				•	•			Effective Quality control
Large power consumer with non-communicating meters, meter reading should be done using Meter Reading Instruments (MRI)	- MRI reading to be done by the competent authority			•	•			•		Eliminate error in meter reading.
SMS with meter reading date can be explored to ensure availability of consumers at the time of meter reading and consumption recording	- Consumer to be intimated related to meter reading and consumption before generation of bill	•				•		•		Increases Customer satisfaction.
Spot billing with/without revenue collection	- Spot billing through with/ without revenue collection facility should be explored.			•	•		•	•		Reduces time related to Meter to Cash cycle and increase avenues for customer to pay

Assess the potential for group meters and Infrared ("IR")/ Bluetooth	-	Alternate meterization for high loss areas/ bulk unmetered areas e.g. single point supply from DTR			•	•		•			
Mobile app for field force management can be developed for tracking the coverage on a daily basis during the meter reading calendar	-	Mobile app to be developed for tracking of meter reading.			•		•		•		Effective Quality control
Develop SLAs and incentivise meter readers for achieving the KPIs	-	Service level agreement and incentive mechanism should be devised for achieving the KPIs related to meter reading and billing.	•				•	•			Effective Quality control

Table 81: Business process improvement action plan
Short term (0 – 6 months), Medium term (6-12 months) and Long term (More than 12 months). Source:
PwC analysis based on KPLC's information

a-6) Recommendations on additional KPIs for tracking billing and collection

3.345 The Key performance indicators for monitoring the billing and collection by the management are as given below:

KPI topic	Measured parameter	Usage
Billing SLA achieved	Time from when batch billing begins and completes compared to the negotiated SLA.	Can be used as a benchmark to determine efficiency of billing
KPI topic	**Measured parameter**	**Usage**
Number of active KPLC customers on a given rate	Provides a volumetric picture of how many customers are there on a given rate. This metric would help a KPLC to understand the impact of the rate change or update.	This metric may be generally used with changes that are made to existing rates. For instances of new rate, it can provide information on count of customer for which this new rate needs to be assigned to.
Total number of outstanding billing exceptions per day	Total number of outstanding billing exceptions per day	Can be used for analysing the need for additional Customer Operations Representatives. An increasing trend will impact cash flow and revenue
Number of Long Bills	The number of bills created in excess of standard billing window (e.g., 32-34 days or greater)	Can be used to evaluate the effectiveness of batch billing process

Table 82: KPIs for billing monitoring
Source: Secondary analysis

c) Revenue collection and arrear recovery

b-1) **Background**

3.346 Revenue management is the process of managing the revenue generation activities and prevention of revenue leakages that a power distribution company faces on a day to day basis. The process begins with the key component of being able to process payments from different sources as well as how to manage payment corrections.

3.347 Revenue Cycle Management ("RCM") is one of the most important processes in a power distribution business. An efficient RCM is imperative for commercial viability and better financials of the distribution company. The key objectives of effective RCM are:

i. Ensuring complete and appropriate metering of consumers
ii. Accurate meter reading and billing with 100% bill distribution
iii. Improving billing and collection efficiency
iv. Keeping a regular check on outstanding arrears and facilitate initiatives for arrear management

3.348 The revenue management and credit control is a critical element in the retail supply business because it directly affects the financial losses and affects cash flow.

b-2) **Process Map**

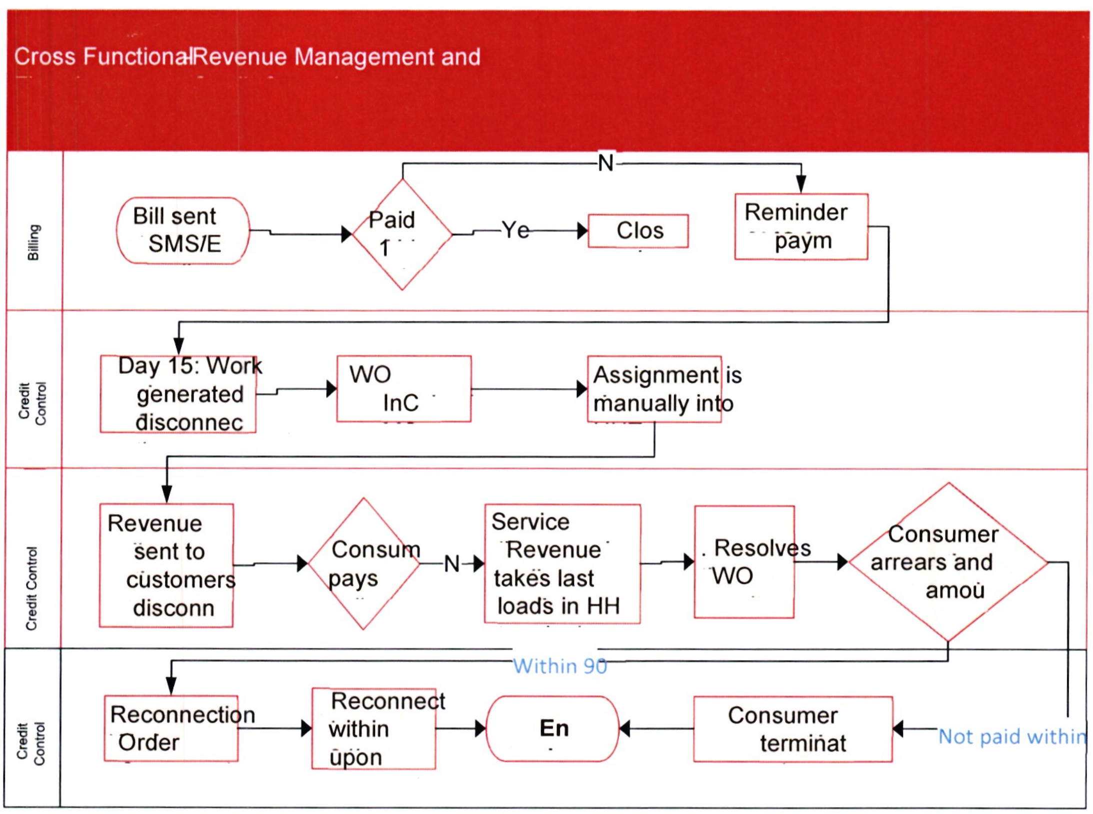

Figure 11: Revenue management and credit control flowchart
Source: KPLC

b-3) PTOF framework: Key observations – Gaps – Improvement opportunities

Sl	Parameter	Key observations	Key gaps	Improvement opportunities
1	**Process**			
1.1	Credit period	• Post-paid consumers are given an initial credit period of 14 days post issuance of the monthly bill. KPLC sends reminder SMS to consumers after 14 days from date of submission of bill. • Non-payment results in disconnection of supply and account's closure where a disconnection is done and there is no payment within three months • There is no approved procedure for checking the connections of consumers disconnected due to non-payment.	• No interest is charged on balances in arrears • Communication for credit is predominantly done through SMS on the registered mobile numbers of the consumers. • There is no approved procedure for site verification of status of consumers disconnected due to non-payment	• KPLC can deploy a charge, based on the approval of the Regulator, for levying of interest on the outstanding amount i.e. arrears. This will promote consumers to pay their bills within the credit period. • While SMS reminders are sent, the contact center agents can be utilized for tele-calling for bill payment reminder for large Power customers. • KPLC can develop a mechanism for verification of disconnected consumers to check their connectivity in the premises
1.2	Bill generation	• The billing system (InCMS) freezes meter readings of large power consumers on the last day of the month. The cycle for noncommunicating / AMR large power consumers is from the 1st to the 4th of each month. • For corporate consumers, the billing is done on 4th of each month • Bills are generated after quality checks and sent to customer by SMS or email (for large power).	• For large power consumers, KPLC's large power department telephonically confirms from the consumers to check the receipt of the bill by the consumer. However, such services are not extended for other consumer categories on a structured basis, which can lead to consumers who have not receive the SMS with the bill details	• Sample consumer bills of other consumers categories should also be checked, especially SMEs or any other high value consumers classified above 5kW or 10kW connections.
1.3	Arrears	• When the consumer pays the outstanding amount along with reconnection charges, reconnection Work Order is generated in the system. • The above process applies to all consumers. In case of premium customers , large power accounts, SMEs with smart meters, disconnection are done online	• KPLC's commercial services and large power teams generate reports to track orders signed and resolved. However the WO management system is not integrated with the AMI system	• KPLC should leverage the AMI of large power to integrate with eth Work Order management system for real time tracking of disconnection and reconnection
2	**Technology**			
2.1	Work Order (WO) management	• Disconnection/reconnection WOs are generated for all non-payment cases in InCMS. Assignment of WO is done manually in Debt Management module • Disconnection and reconnection are effected through WO management system.	• There is no real time dashboard available for disconnection /reconnection for tracking of the disconnections/ reconnections through the WO management system	• Development of dashboard in the existing Work order system to track the WO management activities
3	**Organisation**			

Sl	Parameter	Key observations	Key gaps	Improvement opportunities
3.1	Capacity	• As per KPLC, the supervision for disconnection and reconnection is managed by county sector head, and the supervision for revenue is done by sector head as there are no exclusive manpower at sector level for revenue management	• As per KPLC, there is a shortage of skilled technicians who can disconnect power supply • At present there are 317 revenue collectors, which is below the actual requirement communicated by the credit control team of KPLC, according to the Revenue Management and Credit Control. It was stated that KPLC's credit control team, the number of revenue collectors actually required by KPLC is approximately 530.	• KPLC can develop training and upskilling programs for revenue collectors to train existing and additional staff for work on electrical domains.
4	**Facility**			
4.1	Work order management	• Work Orders are downloaded in handheld terminals. Supervisor will download literary to handheld terminal for allocation to revenue collector • As per KPLC's process document, supervisor act as per the orders classified, in the sequence of literary which have the highest defaulted consumers	•	
4.2	Payment	Payment mechanisms established by KPLC: • Over the counter payments through all Equity Bank branches • Postpaid Electricity Bill with M-Pesa • Payment for prepaid tokens through Equitel service • Cash Payment at KPLC's authorized pay points which are located within official premises • ATM Payments through accounts with Cooperative Bank, Postbank or Standard Chartered Bank • Bank Payments through appointed Co-operative Bank branches • Cheque Payments • Bill Payment Through M-Banking, where customers have to register their account number with the bank	• The existing payment methods are consumer driven, which can lead to delay in revenue collection.	In addition to the existing payment modes, KPLC can deploy cash collection agencies in areas with less revenue collection during the end of the collection cycle for the calendar month. This will help to promote revenue collection drives to maintain the cash flow

Table 83: PTOF framework: Key observations, Gaps and Improvement Opportunities
Source: PwC analysis based on KPLC's information

b-4) Benchmarking exercise

Revenue collection

Utility	Country	Practice
KPLC	Kenya	- Through online, mobile money, cash, bank payment, cheque, M-PESA
TSSPDCL	India	- Cash, Mobile wallets, Payment gateways (credit card, debit card, UPI) - HT consumers though National Electronic Funds Transfer (online) mode only
CESC	India	- Mobile van for cash collection are sent to areas which have due date for bill payment
Tata Power	India	- The payment of monthly electricity bill of all categories of consumers except Domestic, Agriculture & Mushroom cultivation exceeding Rs. 20,000 (KES 30,000) are necessarily paid digitally through various platforms like NEFT, RTGS, IMPS, Credit Card, Debit Card, Wallets (like PayTM, Google Pay) etc
BRPL	India	- EMI facility provided, which is an arrangement between the consumer and their card issuing bank with BRPL having liability
MSEDCL	India	- MSEDCL advertises the online mode of payment through its website, app and printed bill copies - MSEDCL had also filed a petition with MERC for approval of pass through expenditure towards discount on digital payments. A rebate of 0.25% for LT consumers has been approved by the commission for digital payments. - Mobile app provides the location of the nearest collection centers

Table 84: Revenue collection benchmarking Source: Secondary research

b-5) Improvement opportunities

3.349 We have developed an Action plan for improvement in Business process as below and segregated into Short term (0 – 6 months), Medium term (612 months) and Long term (More than 12 months).

Legend

NC	C	P	T	O	ST	MT	LT
Non capex/ Low capex	Capex	Process	Technology	Organization	Short term	Medium term	Long term

Name of activity	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
Charges on arrears	• Levy of charges on arrears in bills to discourage consumers from defaulting. This can be done based on approval of the Regulator	•				•	•			
Quality control	• Conduct quality control of bills sent through SMS, by deploying the call centre and field staff for second level verification	•	•				•		•	

Name of activity	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
Local electricity representative appointment as additional support to KPLC's existing manpower	• Representatives of the company to be appointed for spreading various scheme details; bridge between consumers and KPLC	•	•				•			Improve brand image of KPLC among consumers
Rebate for prepayment in case of post-paid connections	• This can be done based on approval of the Regulator	•				•	•			This will help to incentivise against defaults
Village representative appointment, banking correspondents and rural commercial centers	• These representatives shall be responsible for meter reading, bill distribution, revenue collection, receipt of complaints and follow up.	•	•		•		•	•	•	Reduction in regular employee cost and better reach in villages. They will serve as additional manpower for meter reading, billing, bill distribution, revenue collection
Scheduled site visits communicated to the consumers through SMS	• Prior notifications to consumers of KPLC staff site visits - revenue collection, complaint registration, resolution of queries	•	•				•	•	•	Enhance consumer interactions and increase in revenue realisation
SMS based reminder system for consumers with multiple default of payments	• SMS based reminder related to present bill and arrear recovery, to consumers with multiple default, irrespective of the billing cycle	•	•				•			Continuous follow-up with customers is required for bill collection and arrear recovery.

Table 85: Improvement Opportunities

Short term (0 – 6 months), Medium term (6-12 months) and Long term (More than 12 months). Source: PwC analysis based on KPLC's information

d) Vigilance and Commercial monitoring

d-1) Background

3.350 Electricity theft is the root cause of the commercial loss of electricity distribution companies. It leads to overloading power distribution systems, power disruptions, poor quality of supply and higher electricity tariff burden on consumers.

3.351 The basic principle for electricity theft is tampering with the metering of electric energy which can affect the metering of voltage, current and power factor.

3.352 We discuss some KPLC reports related to vigilance and monitoring.

i) Technical Audit Report No 01-2020/2021 - Large Power Audit- Nairobi West and South Sub counties stated that there are customers who have access and control over the meters in their premises. (7 out of a sample of 68 meters can be freely accessed by customers). The report also indicates that there exist terminated accounts which still have intact connections. This makes it easy for self-reconnections.

ii) Technical Audit Report No 12-2020/2021 - Large Power Accounts Audit- Coast Region indicated that meter replacements take along period before its done. In this report, there are customers who had established faulty meters taking over 6 months without being replaced. The customers would be billed based on their historical consumption. Other customers have two meters existing in their premises and so the old idle meter would be used for billing. Zero billing for a customer with a faulty meter. There is no rebilling for the same customer and that could be an indicator of customer underbilling.

iii) Large Power Audit – West Kenya Region: Technical Audit Report 2021/2022-03 and Revenue Assurance Report RA 2021/2022-02 - Indicates that there are faulty accounts which are manually and had inaccurate readings that were used in billing. Some had mixing up of High Rate and Low Rate units. This could result in customer being overbilled or Underbilled. The report indicates that Faulty Meters do take too long to be replaced and when replaced customers are not debited for the lost units.

d-2) Process Map

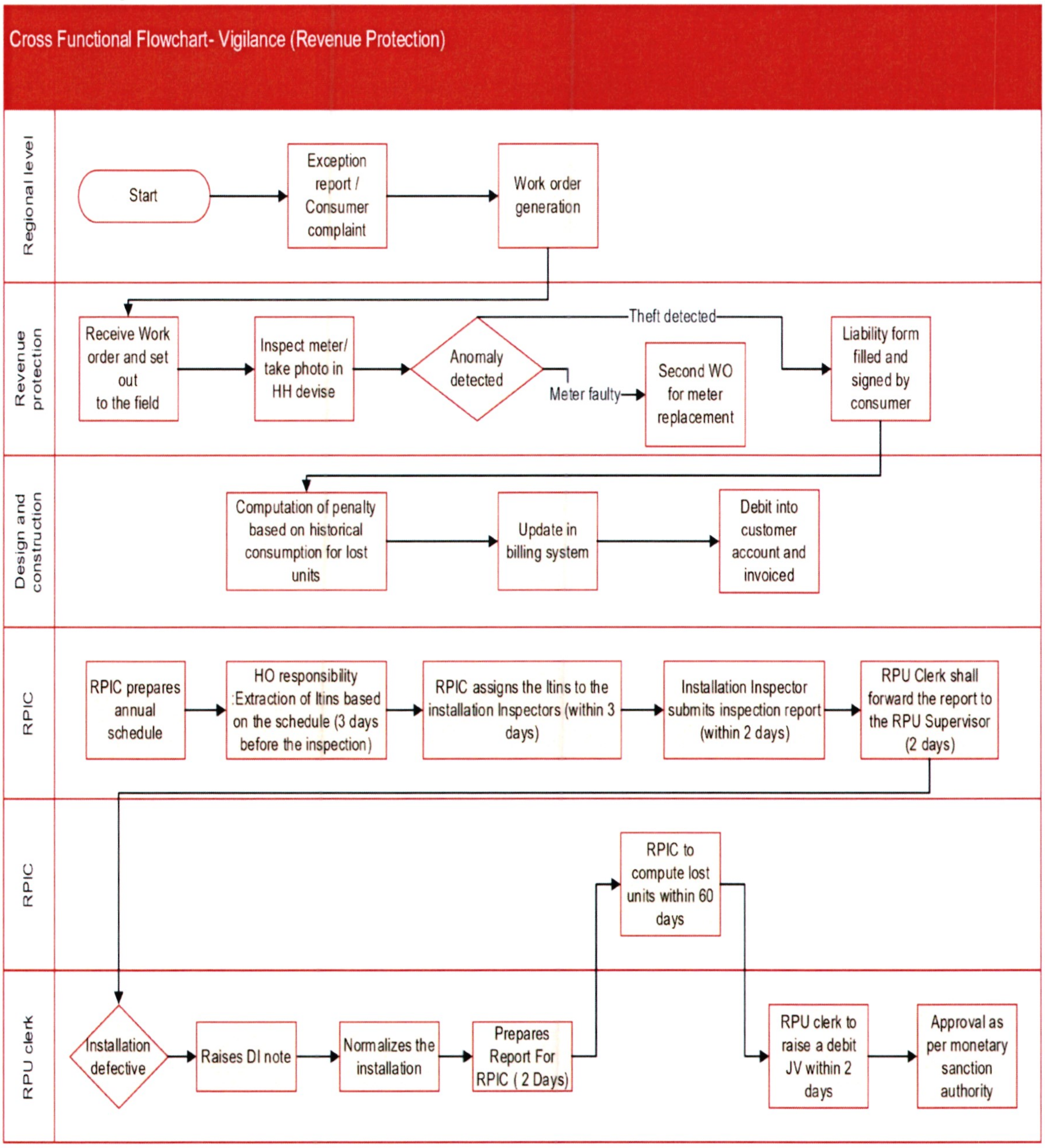

Figure 12: Revenue protection flowchart
Source: KPLC

d-3) PTOF framework: Key observations – Gaps – Improvement opportunities

Sl	Parameter	Key observations	Key gaps	Improvement opportunities and benefit
1	**Process**			
1.1	Inspection	• Installation inspection process covers the measurement of accurate metering, metering accuracy, replacement of faulty meters, rectification of metering anomalies, meter bypasses, capturing the evidence of anomalies or direct supply and filing anomalies		• Integrated feeder-wise performance monitoring systems, installing aerial bunched cables for LV connections
1.2	RPU functions	• As per the ISO 9001:2008 QMS, Revenue Protection in Charge (RPIC) should prepare an annual schedule for installation inspection. • The RPU supervisor should provide requisition for the ITINS based on the schedule and three days before the inspection. • In case of ordinary accounts, the RPIC assigns the ITINS to installation Inspectors within 3 days. The Installation Inspector compile and forward an inspection report for each account to the RPU clerk within 2 days. The RPU Clerk should record in the installation Inspection Register and update cases to be followed up in the incidence window. The RPU Clerk should forward the report to the RPU Supervisor for follow up within 3 days	• The request for ITINS is placed by the RPU supervisor to the corporate office team and through the Chief Customer Service Engineer. Ideally, the Customer Service Engineer should proactively send the ITNIS to the supervisor irrespective of the requisition and within a predetermined data • There is no escalation mechanism for adherence to timelines of tasks between the RPU supervisor and the other stakeholders	• For charging consumers for theft cases, online load calculator and duration as per Regulation should be developed. • There should be a tool which can have the matrices to track the lifecycle of the inspection process for any consumer account.
1.3	Computation	• For calculation of lost units, the recovery period is 6 months for faulty meters. However, if the faulty meter is reported by the customer, the recovery period is 30 days.	• There is a risk that consumers with tampered meters can report them as faultly to avoid incurring the 6 months recovery charges and other penalties. This is because in KPLC does not test the meters for cases where the consumers report them and only recover upto 30 days.	• Testing should be made compulsory and historical consumption should be analyzed in case of faulty meter is reported by the consumer. This would reduce the underestimation of units lost due to faulty meters..

1.4	Large Power inspection	• Activities on losses of large power – Large power consumers' billing is done on 1st date of the month. Loss reduction activities include analysis of bills with using exception report, PF, missing current, works on exception report. For large Power, the regional managers update the site findings from 4th to end of the month. The finding reports are sent to the RPU. Large Power teams have to inspect each consumer twice every year.	• Large Power teams have to inspect each consumer twice every year, however as per practice, this target is not achieved. For the year 2022-22, approx. 5800 large power consumers were inspected from July 2021 to March 2022, out of targeted 7036 nos.	• KPLC should strengthen focus on inspection of large power consumers. This will require strengthening of manpower and equipment adequate to ensure that each large power consumer is checked twice in the year • Additional check can be done on month wise comparison of billing units against previous year same month period.

SI	Parameter	Key observations	Key gaps	Improvement opportunities and benefit
1.5	Exceptions	• For exception on Large Power consumers reported for exceeding sanctioned load, notification letter is sent to consumer for additional load application. • As per the ISO defined process, Large Power Coordinator should analyze for any applied/paid for applications for additional load and issue notice to consumers within two days for application of additional load	• There is no mention of penalty for exceeding the sanctioned load as per the Energy Act or Customer Charter of KPLC. However, consumers can be disconnected if they fail to augment the sanctioned load.	• KPLC should develop a documented procedure to penalise consumers for excess of sanctioned load, where disconnection cannot be effected due to reasons beyond KPLC's control
1.6	Computation of energy loss by RPU	• For charging consumers for theft, manual computation is done based on historical consumption available in the billing system. The theft amount recovery report is available in InCMS but has to be downloaded by Head office team and sent to respective counties	• Historical consumption may not reflect the seasonality and the possible quantum of power during the period established under pilferage.	• Estimation of units based on a factor of the sanctioned or connected load would provide upper limit of power drawn by the consumer.
1.7	Computation of energy loss in metering manual	• Methods for computation are: • Using six months average consumption prior to the interference • Average consumption recorded by the replacement meter • Average consumption recorded by the new meter after direct connection is removed/normalized • Using one to two years average consumption for irrigation supplies • Check meter results	• The computation of lost energy is in the approved procedure does not consider the connected load / sanctioned of the consumer	• KPLC can develop an energy loss calculation mechanism based on connected load and load factor. This will help to avoid under-consideration of abnormal consumption during the period of energy theft
2	**Technology**			

2.1	Tools	• As per KPLC, the RPU does energy balancing which includes computation of input energy versus billed energy.	• The calculation is done based on feeder meter data reading taken by county engineers. The county engineers are also responsible for operation and commercial activities. This can lead to delay in computing the energy balance	• KPLC can develop an internal portal for the update of readings, report, photograph etc.
	Analytics	• Exception report is generated by the system . Exception reports are generated after every billing which include cases of zero bills, non-vended accounts, zero vended accounts, complaints on faulty meters reports for ordinary account etc. • Exception reports for ordinary accounts are generated in ITRON. Such reports include zero vend, non-vend, zero consumption cases. • Based on exception reports, Work Orders are created for site analysis. Site report are captured in handheld units and the reports have to be downloaded from the system	• Data analytics for large power consumers' consumption pattern is done by KPLC's teams. However, KPLC's team have highlighted the need for capacity building to leverage the smart meter data captured.	• KPLC can develop an integrated dashboard for tracking and monitoring of exception reports summary on a daily basis • Workforce management app can be developed to assign tasks on a real time basis for rectification and reposting of exceptions • For ordinary accounts, reports have to be downloaded from the system, so target should be set for every region/county.

Sl	Parameter	Key observations	Key gaps	Improvement opportunities and benefit
2.2	Monitoring	• Non-payment results in disconnection of supply and the account's closure if the disconnection is done and there is no payment within three months	• There is no approved procedure for checking the connections of consumers disconnected due to non-payment	• Inspection schedule of disconnected cases for nonpayment should be developed, with priority on high consumption accounts
3	**Organisation**			
3.1	Verification	• RPU department facilitates to check the connection load, energy theft , trace application where direct supply is found and liaison with infrastructure dept to connect the customer • Also, in cases where a meter is found on site but not traceable in the billing system, KPLC works with the consumer to help them apply for the connection and regularize the supply. • Report on the recovery of applicable penalty for theft is available in InCMS. The report has to be downloaded by Head office team and sent to respective counties for actions on monitoring.	• There is no defined process around inspection of services previously charged with cases of electricity theft • There is no exclusive court for dealing with electricity theft cases	• KPLC can develop capability for inspection of services where theft was detected more than once in a specific period (e.g. 1 year or 2 years) • KPLC can also promote informer incentive schemes for reporting of electricity theft by consumers.

3.2	Manpower	• KPLC has in house manpower for inspection: At present, there are 301 inspectors, including 67 for large power	• Considering the consumer base of 8 million for KPLC, this translates to 1 inspector responsible for approximately 26,000 consumers	• KPLC can consider the requirement of manpower for inspection
3.3	Work order management	• Work Order for inspection is generated by sector in charge, who assigns to field staff for site inspection and reposting. A second Work Order is generated for rectification of the services based on the report of the first WO.	• This is a two-step process, which can be reduced in cases where rectification is possible in a single visit.	• To optimize the manpower and effort, KPLC should have mobile teams equipped with tools and equipment Conversely, WO management can be done through mobile based solutions
4	**Facility**			
4.1	Exceptions	• Inspection for prepaid meters predominantly include cases where the meters are not vending. As per KPLC's experience, it can be due to theft as well as vacant or demolished premises.	• Non vending can be due to bypass of meters leading to theft of electricity and directly affects the distribution loss. However, there is no specific technique to determine the vacancy of the premises, which requires deployment of manpower.	• KPLC can devise a mechanism where consumers can preemptively inform the respective county offices/ online centers the details of duration of vacancy of premises.
4.2	Capacity building	• As per KPLC's metering Manual routine inspections are done for based on reports on o consumption deviation found on the higher side of ±30%, o load factor i.e. consumption units not commensurate with the load connected (deviations of less than 15% or greater than 85% for action) o Consumption outside tariff range of 15000 units	• For large power consumers, large power team leaders are supposed to confirm the reason for deviations. e.g. no loads have been connected hence nil consumption in the installation within that billing cycle. However, the large power team of KPLC highlighted the lack of skilled manpower to complete the two	• Provision of skilled staff with handheld sets and test equipment, tool kit, power analyser should be ensured by KPLC • Training of staff for better utilization of tools and equipment.
Sl	**Parameter**	**Key observations**	**Key gaps**	**Improvement opportunities and benefit**
		o Zero consumption i.e. nil consumption within a billing cycle. o Supplies exceeding authorized kVA for regularization follow ups. Customers are given 30 days to regularize the connection of additional loads. o Supplies with power factor of less than 0.90 (lagging or leading)	inspections for each large power consumer every year.	
4.3	Enforcement	• For assisting in the vigilance process, the security dept is involved in case of arrests. But this support is availed on need basis		• Controlled energy theft using special police forces; Community participation to improve O&M including theft prevention

4.4	Vacant premises	• Inspection for prepaid meters predominantly include cases where the meters are not vending. As per KPLC's experience, it can be due to theft as well as vacant or demolished premises.	Non vending can be due to bypass of meters leading to theft of electricity and directly affects the distribution loss. However , there is no specific technique to determine the vacancy of the premises, which requires deployment of manpower.	• KPLC can devise a mechanism where consumers can preemptively inform the respective county offices/ online centers the details of duration of vacancy of premises.

Table 86: PTOF framework: Key observations, Gaps and Improvement Opportunities Source: PwC analysis based on KPLC's information

d-4) Benchmarking exercise

Utility	Country	Practice
KPLC	Kenya	launched a loss reduction initiative dubbed 'The War Room' in February 2021 to spearhead system loss reduction initiatives
TSSPDCL	India	Separate department for checking the services of HT consumers
Tata Power	India	Flying squad established for loss reduction activities
CESC	India	
Torrent Power	India	Installation of Arial Bunched (AB) cable in theft prone areas
MSEDCL	India	High Voltage Distribution System (HVDS) in rural areas to prevent energy theft from direct hooking
BRDP	Bangladesh	System Loss Reduction Pilot Scheme

Table 87: Vigilance and Commercial Monitoring benchmarking Source: Secondary research

d-5) Action plan for improvement in business process

3.353 We have developed an Action plan for improvement in Business process as below and segregated into Short term (0 – 6 months), Medium term (612 months) and Long term (More than 12 months).

Legend

NC	C	P	T	O	ST	MT	LT
Non capex/ Low capex	Capex	Process	Technology	Organization	Short term	Medium term	Long term

Name of activity	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
Enhance the calculation of penalties and unbilled units	• Assessment of lost units due to theft are currently done through analysis of customer's historical consumption. The computation of lost energy does not consider additional parameters based approved load or the connected load at the time of the inspection. Approved load is the load (kVA) as per KPLC's contract with the consumer, whereas the connected load is the actual load of appliances found during the inspection.	•				•	•	•		
Inspection of large power consumers	• Enforce the requirement for a physical site inspection and installations testing at large consumer twice a year. Avail the resources required for this exercise • Follow-through with inspections and investigations where there is suspicion of malpractices	•	•				•		•	
Data analytics	• Billing data analytics of LV consumers- centrally at corporate office.	•	•				•	•	•	Targeting consumers for high task efficiency
	• Meter reading data (MRD) analysis of LV consumers in phased manner.					•				
Director- Loss reduction	• Separate department for loss reduction to be constituted for focused loss reduction.	•				•	•		•	Focussed approach towards loss reduction
Consumer segmentation based on load	• Key High value consumers to be identified for focused approach towards technical and commercial activities.	•				•	•		•	Focus on 80:20 rule to ensure high impact with minimum effort
IT tool	• IT tool for registration/ filing of theft case including calculation of penalty amount and tracking till collection of penalty amount			•	•		•	•		Increase accuracy in recording of theft case, calculation of penalty and tracking of case
	• Workforce management app with calculation of penalty, photograph etc.									
Regular testing of meters including faulty meters	• Regular testing of meters including faulty meters to be done by discom staff	•				•	•			Monitoring of meters should be done to reduce commercial loss
Regular targeted testing and inspection of High value consumer meters and associate accessories	• High value consumers to include HT and LV high value consumers.	•				•	•			Monitoring of meters should be done to reduce commercial loss

Inspection of services where theft was earlier detected	• Inspection of connection where theft was earlier detected by discom.	•				•	•			Monitoring of meters should be done to reduce commercial loss

Name of activity	• Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
Informer incentive scheme	• Percentage sharing of revenue by discom to person providing information related to theft.	•	•				•		•	Increases coverage of commercial monitoring
Dedicated mobile teams for inspection with provision of handheld sets and test equipment, tool kit, power analyser.	• Mobility for inspection of operational network	•			•				•	Increases operational efficiency of vigilance teams
Mechanism where consumers can pre-emptively inform the respective county offices/ online centers the details of duration of vacancy of premises.	• Theft prevention via information to KPLC	•	•						•	Increases coverage of commercial monitoring of consumers especially in rural areas.

Table 88: Action plan for improvement in business process

Short term (0 – 6 months), Medium term (6-12 months) and Long term (More than 12 months).
Source: PwC analysis based on KPLC's information

e) Customer services

e-1) Background

3.354 Managing customer service involves the definition, collection, and management of key performance metrics related to KPLC's interaction with the consumer. It requires both automated and manual integration with the affected business processes and business flows to extract the applicable data, perform analysis, and take actionable improvement steps.

e-2) Process

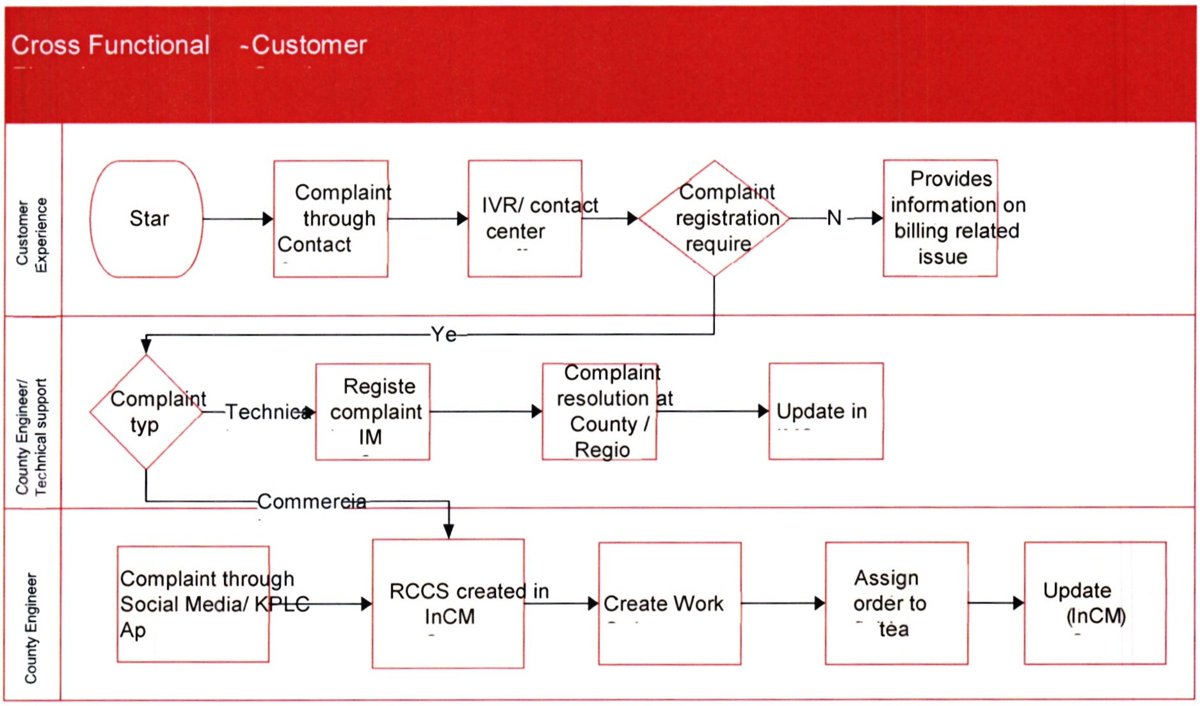

Figure 13: Customer service flowchart
Source: KPLC

e-3) PTOF framework: Key observations – Gaps – Improvement opportunities

Sl	Parameter	Key observations	Key gaps	Improvement opportunities and benefit
1	**Process**			
1.1	Registration and redressal	• KPLC's Contact Center and Customer experience departments manage consumer complaints. • KPLC's contact centers are provided with Interactive Voice Response(IVR). Complaints from same area are mapped to reduce the load of incoming calls • Tokens generated for registered complaint • Power outage complaints are registered in IMS and transmitted to the technical center. For major power outage e.g. outage of a high voltage feeder, incident is created by the technical team. This gives the customer care the mapping of all accounts mapped to the feeder. • Rectification Job assigned to the field staff by Technical team Emergency Desk operator. Post resolution, Emergency Desk operator update in IMS	• There is no complaint related automatic escalation matrix in KPLC • SMS is sent to the consumers about the technical issue in the network in case of technical complaint. But KPLC team teams have acknowledged that this is not done in all cases	• KPLC can study the feasibility to introduce technologies like Chatbot and Voicebot which will reduce the call flow into the call centers • The complaints registered and beyond the defined SLA timelines should be routed through an auto-escalation matrix to the next level of responsible engineer/ manager, for e.g. supply interruption complaints for more than 5 hours in Central business districts of Nairobi, Mombasa, Eldoret, Nakuru and Kisumu.
1.2	Charter timelines	• As per the Customer Charter, the timeline for permissible duration of power outage is 5 hours in urban areas and 8 hours in rural areas	• As per the data available for FY 2021-22 up to February, the resolution rate is 90% within 4 hours in urban and 92% within 8 hours in rural	• Better mobilisation of operation and maintenance staff, use of field force management technology and vehicle tracking application can help to reduce breakdown time. • Developing maintenance process and procedures will help to prevent breakdowns
1.3	Distribution transformer failure	• As per the data given by KPLC, 2121 nos. distribution transformers were recorded to have failed in the 6 month period of December 2021 to June 2022. Considering the distribution transformers population of KPLC as 8,778 (as per Grid and customer data sheet) as on FY 2021, the annual failure rate would be approximately 48%.	• This is significantly high considering the predominance of urban consumer base of KPLC. When compared to similar sized power utilities in India, the distribution transformer failure rate is found between 7 to 11 percent over the last four years.	• Maintenance of existing DTR meters , modems, SIM etc. • Monitoring of input of DTRs on 15 days/ monthly basis
2	**Technology**			
2.1	Channels	• Mode of complaints registration : through 24x7 customer care call center, Mobile app, Social media, WhatsApp (for billing issues), Email and Telephonic call.	• Complaint is allocated to the field team's Handheld terminals, through InCMS. Also, the Emergency team uses radio/ telecommunication to contact the desk operator There is no field	• Provision of automatic registration of power outage complaint from the HES to the IMS portal for smart meters

Sl	Parameter	Key observations	Key gaps	Improvement opportunities and benefit
		• Consumers can also walk into the banking halls for complaint registration • For commercial complaint , e.g. faulty meter, rebilling, WO is created for site visit and resolution at the regional level.	force management tool to track the activities	
2.2	Dispute	• As per the Customer Charter (Meter Testing), if a consumer is not satisfied with the outcome of the review of the bill, they may request for a meter test at his/her premises. KPLC will install a meter testing device to monitor the readings of a disputed meter recording for a period not exceeding 30 days. The meter testing results shall be communicated to the customer within 2 weeks after the testing period. • If the meter testing results demonstrate that the meter is faulty, the meter shall be replaced at KPLC's cost and if the customer insists on the replacement of a healthy meter, the customer shall bear the cost of meter replacement	• The existing process can lead upto 1.5 months for resolution of the dispute , which leads to blockage of working capital from the cases where the meter is not found defective	• KPLC can deploy the services of mobile testing facilities to test meters at site and generate the meter testing report within a period of 5-7 days from the date of complaint registration
3	**Organisation**			
3.1	Manpower	• Customer experience representatives are located at the county level. They address issues within the particular county.	• There is dedicated team for addressing large power consumers. However, there are no specific policy on engagement of consumers for raising awareness on loss contributing issues	• KPLC can organize customer meetings to receive feedback and resolve issues related to large power and other key consumers
3.2	Tools	• Customer charter parameters are tracked in excel based formats at the end of the month for all counties. Reports are downloaded from InCMS	• There is a lack of real time tracking mechanism of customer charter parameters	• Development of a tool for tracking and report customer charter parameters
4	**Facility**			
4.1	Manpower	• The contact centers have KPLC's In house manpower, around 185 staff in 3 shifts • There are two contact centers located in Nairobi, in which one serves as the backup	• As per KPLC, the AMI regional control centers are not fully functional.	

Table 89: PTOF framework: Key observations, Gaps and Improvement opportunities
Source: PwC analysis based on KPLC's information

e-4) Benchmarking exercise

Customer Service Avenues

Utility	Country	Industry Practice
KPLC	Kenya	- Call center + IVRS - Consumer walk in - Mobile app - Social Media
TSSPDCL	India	- Call center + IVRS - Website - Mobile app - Email
Tata Power	India	- IVRS - If key consumer calls, the system flags for direct connectivity to executive - Quick Response Teams placed at Call Centre and Back Office to deal with escalated complaints
BRPL	India	- BSES has launched Digi Seva Kendra to provide 'single window services' - Consumers can book a prior appointment for the DSK through the BSES website and mobile App
BRDP	Bangladesh	- Grievance redressal system: Online submission of complaints - Digital services: Bill On Web, Pre-Payment Metering System, Computerized Billing System - Other e-services: New Electricity Connection, E-Tender, Stores and fixed asset management methods, Solar Energy (Net Metering) Calculator
Lanka Electricity Company (LECO)	Sri Lanka	- Customers can access LECO management or relevant staff anytime through telephone, fax, e-mails, letters or walk through visits. - MYLECO Mobile Application is available for any registered customer to interact any inquiry like breakdowns complaints, electricity bill related information and payment history - Dedicated team in the customer service center

Table 90: Customer Service Avenues Benchmarking
Source: Secondary research

Monitoring

3.355 In order to monitor complaint management, resolution status and escalation in case of no action by the field staff, various reports and dashboard can be prepared in IT platforms; please find below the industry practices in this regard:

Utility	Country	Practice
KPLC	Kenya	Reports generated by the users from InCMS/IMS
TSSPDCL	India	Mobile app developed for tracking complaints and allocating jobs, used by field engineers and field supervisors
Tata Power	India	Real Time Dashboard Monitoring with Call Escalation: 1st level -Supervisor / QA executive 2nd level -Operations Manager 3rd level – County Team 4th level – Head of the Region Auto Escalation of Complaint through System TPDDL has implemented the Integrated Outage Management System integrating CRM, SCADA/DMS, SAP PM, AMI and GIS

BRPL	India	CRM tool is used for management and tracking

Table 91: Customer Monitoring Benchmarking Source: Secondary research

3.356 The customer charter parameters tracked by KPLC are given as an Annexure. **e-5)**

Action plan for improvement in business process

3.357 We have developed an Action plan for improvement in Business process as below and segregated into Short term (0 – 6 months), Medium term (612 months) and Long term (More than 12 months).

Legend

NC	C	P	T	O	ST	MT	LT
Non capex/ Low capex	Capex	Process	Technology	Organization	Short term	Medium term	Long term

Name of activity	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
Updating of mobile numbers of consumers for SMS and voice call updates	For KPLC to interact with customers, mobile number needs to be updated on a regular basis.	•	•							Communication with the consumer is required related to outage information, complaint management etc.
Mobile based Social media platforms with AI chatbot for automatic complaint registration	For usage for business purposes for customer care services intimation and interactive platform for complaint registration and information			•		•		•		Current Social media platforms act as virtual chatbots for information related to bill, complaint registration etc.
Use of Chatbot and webservices and E-mail	IT tools to be used for increasing avenues for consumer complaint and requests management			•	•			•		KPLC's IT platforms can be used by the Customer care department for monitoring complaint registration and resolution status.
Use of Cooperative or Self-Help Group services	Use of SHGs for rural complaint management and servicing requests			•		•			•	In rural areas, the vast geographical areas are difficult to cover by outnumbered utility staff; local SHGs can be used as support staff for complaint management.
Centralized Call Center (CCC)	Located at KPLC Headquarters and adequately staffed to receive complaints even during peak seasons.			•	•		•			CCC of KPLC should cover the entire KPLC operational area and should be accessible by the customers via different media such as mobile apps, chatbots etc. which can be integrated with the billing database of consumers for information sharing with the customer by the CCC representative.
Mobile app-based services with chatbot or voice-bot for automatic complaint registration	Customer to be provided Mobile app-based services so that even in Covid pandemic conditions, discom can receive information request.			•	•			•		App-based services are the industry practices that should be used by KPLC and its customers.

Empowerment of Field staff with IT tools for complaint management	Field staff to be provided with a mobile app and web-portal for receiving complaints from CCC and also update status related to resolution of complaints.			•		•			•	Field staff should be provided with a web-portal and mobile app for complaint management and resolution status which can be informed to CCC.
Name of activity	**Activity description**	**NC**	**ST**	**C**	**LT**	**MT**	**P**	**T**	**O**	**Impact/ Benefit**
Feedback mechanism for consumers	Provision of feedback via E-mail, call center, social media related to performance of discom for compliant management.	•	•				•			The feedback mechanism ensures resolution statusOK by customer and improves the operational efficiency of the discom.

Table 92: Action plan for improvement in business process Source: PwC analysis based on KPLC's information

f) Energy accounting

f-1) Background

3.358 KPLC should conduct monthly meter reading at feeder and consumer level and prepare Energy balance reports. Currently, the process is manual based.

f-2) Process map

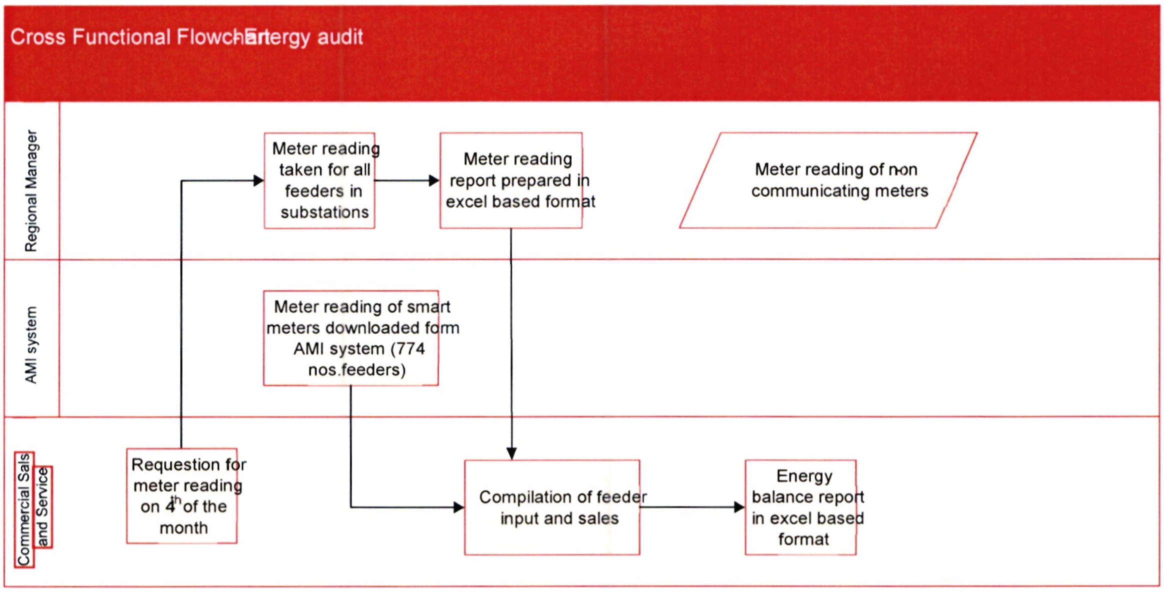

Figure 14: Energy accounting flowchart Source: KPLC

f-3) **PTOF framework:** Key observations – Gaps – Improvement opportunities

Sl	Parameter	Key observations	Key gaps	Improvement opportunities
1	**Process**			
1.1	Meter reading	• Meter reading feeders with smart meters are captured from the AMI system • Meter reading for non-smart meters for energy balance are captured by the Regional offices and transmitted to the Commercial Sales department for computation. • The data is not captured uniformly or compiled in an analysable format. • The schedule for meter reading of feeders is 4th date of the month	• Readings have to be captured monthly as per required schedule, however there are delays the process, e.g. Delay in transmitting the feeder meter readings from the county office to the commercial sales dept for energy balance	• All new feeders should be mandatorily fixed with meters at the substation • Development of an IT portal, integrated with AMI system for automatic generation of energy accounting reports at feeder level • Real Time Data Acquisition System (RT-DAS) can be installed in places where there are no feeder meters/ unavailability of SCADA
1.2	Metering of Bulk Supply Points (BSPs)	• BSPs that are not metered, have faulty meters or where KPLC does not have access to the metering data since the transmission substations are under KETRACO	• metering gaps hinder accurate determination of power that gets into the distribution network which affects the accuracy of the transmission and distribution loss calculations	• This challenge is overcome by leading power distribution companies by having High Voltage side metering by transmission company and Low Voltage side metering by distribution companies. The meter reading of the two sets of meters are verified for billing
2	**Technology**			
2.1	Database for meter readings	• Meter readings are transmitted by the Regional engineers in excel based formats . For calculation of efficiency of feeders, data computation is done in excel based formats for energy balance at 11kV, 33kV and 66kV level • As per KPLC, the Commercial Sales and Service department does energy balancing which includes computation of input energy versus billed energy. This is done for areas of high losses to determine regional energy efficiency on feeders that are metered (95%).	• The calculation of energy balance is done based on feeder meter data reading taken by the regional engineers and transmitted in excel based formats	• Meter readings and load transfers on interconnected feeders have to be accurately captured in a database • IT portal for update of regional report, with photograph • Stakeholders, responsibility and timeline matrix can be developed for accountability

Sl	Parameter	Key observations	Key gaps	Improvement opportunities
3	**Organisation**			
3.1	Responsibility	• Regional Managers are responsible for reading the meters under their jurisdiction.	• The substations are not manned by KPLC's staff, thus periodic capturing of reading (e.g. hourly) is not possible	• Establish an Energy Audit team at the Head Office and Regional levels for Energy audit with responsibility of coordinating the energy accounting processes
4	**Facility**			
4.1	Metering	• According to KPLC, there is 100% regional border metering while feeder metering is at 95%. County border metering is underway with 6 of 49 counties having boundary meters. These include Counties in the Nairobi Metropolitan area. KPLC thus determines power losses distribution across county-based technical assumptions	• Technical assumption can lead to inaccurate calculation of energy accounting reports	• All new feeders must be installed with smart meters at the substation level
4.2	Testing	• There is no existing procedure for periodic testing of feeder meters	• Lack of testing of feeder meters, CT /PT and secondary circuits can lead to erroneous energy balance	• Periodic testing will help to detect any anomaly in the feeder meters, the wiring configuration, CT/PT health etc. • Process manual and inspection schedule had to be developed by KPLC

Table 93: PTOF framework: Key observations, Gaps and Improvement opportunities

Source: PwC analysis based on KPLC's information

f-4) Benchmarking exercise

Parameters	KPLC	TPDDL	MPMKVVCL	TSSPDCL	Torrent Power	AEML	MSEDCL	BRPL
Meter reading using the following technologies								
Consumer indexing- Web based/ GIS		□		□	□	□		□
Nomination of Feeder managers			□				□	
Generation of feeder wise energy loss	□	□	□	□	□	□	□	□
Monitoring of working feeder meters and calibration		□		□	□	□	□	□
Meter reading activity								
Tracking mechanism of Meter readers		□		□			□	
Billing and Bill distribution								
Mobile SMS based bill distribution	□	□	□	□	□	□		□
E-mail based bill distribution	□		□	□				□
Mobile app-based bill view		□	□	□	□	□	□	□
Chatbot			□		□	□	□	□

Table 94: Energy Accounting Benchmarking
Source: Secondary research

Comparative on industry best practices

Name of the Utility		Industry Practice
KPLC	Kenya	- Energy balance done based on feeder meter data received from smart meters and reading by field engineers - Excel based computation
TSSPDCL	India	- Meter reading captured by field engineers - In-house energy accounting portal for energy balance computation - Appointment of Energy Auditor for Quarterly and Annual Energy Audit Report for 11kV and 33kV feeders
Tata Power	India	- Tata Power has installed smart meters in the HT network (33kV, 11kV feeders) and distribution transformers, for energy accounting at each level
BRPL	India	- Tata Power has installed meters in the HT network (33kV, 11kV feeders) and distribution transformers, for energy accounting at each level
MSEDCL	India	- Appointment of accredited energy auditor for annual energy audit and periodic energy accounting

Table 95: Comparative on industry best practices Source: Secondary research

f-5) Action plan for improvement in business process

3.359 We have developed an Action plan for improvement in Business process as below and segregated into Short term (0 – 6 months), Medium term (6-12 months) and Long term (More than 12 months).

Legend

NC	C	P	T	O	ST	MT	LT
Non capex/ Low capex	Capex	Process	Technology	Organization	Short term	Medium term	Long term

Name of activity	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
Energy	Generation of EA report on monthly basis;		•	•			•	•		Baseline loss affects Effective

Name of activity	Activity description	NC	ST	C	LT	MT	P	T	O	Impact/ Benefit
Audit("EA")	Feeder level meterization ; Consumer level meterization									maintenance strategy, meterization and commercial monitoring
SCADA for system loss calculations	Leveraging the SCADA system to enhance system loss calculations	•	•				•	•		Enhanced completeness and accuracy of the loss calculations
										Enable targeted loss reduction interventions
Metering of Bulk Supply Points (BSPs)	Evaluating the installation of meters in the High Voltage side metering by KETRACO and Low Voltage side metering by KPLC			•	•			•	•	Accurate billing of input energy and loss calculation
Data analytics	Automate and use data analytics in the energy accounting process Develop an IT portal for energy audit, aimed to reduce manual interventions and associated interdepartmental dependencies			•		•		•		Enhance efficiency and effectiveness of the loss reduction initiatives
Enhance governance and approach : EA team	Establish an Energy Audit team at the Head Office and Regional levels for Energy audit with responsibility of coordinating the energy accounting processes	•				•	•		•	Achievement of the desired outcome of loss reduction Optimal allocation of resources
Monitoring loss at 33/11 kV S/s	A comprehensive list of all substations shall be developed along with their corresponding losses (minimum, maximum and average figures for past 12 months). The substations with high losses (e.g. exceeding 1.5%) should be targeted first.	•				•	•			Technical loss monitoring

Table 96: Comparative on industry best practices
Short term (0 – 6 months), Medium term (6-12 months) and Long term (More than 12 months).
Source: PwC analysis based on KPLC's information

g) Smart Metering

3.360 KPLC has installed smart meters at various voltage levels. We have discussed issues and provided experience sharing from various utilities related to smart meter implementation. We have also provided sample Service level agreement from smart meter vendors to provide an overview of the various parameters which should be monitored by KPLC.

g-1) Background of smart metering in KPLC

Project background	Communication mode	Issue
• In 2016, KPLC awarded AMI contract to three companies, viz. Hexing Electricals, Lomas & Lomas (Shenzhen Star) and Shenzhen Inhemeter, to carry out AMI pilot project for 3,300 meters each. These agencies separate Head End Systems (HES) to manage the smart meters installed by each of them.	• PLC was used as a mode of communication between meters and Data Collectors (Downlink communication). GPRS used as a mode of communication (uplink communication) between Data Collector and HeadEnd (HES).	• The communication rate was observed to be 70%, leading to no recommendation for use of the PLC technology in future AMI projects As per • KPLC, there is no SLA provision to penalize the agencies for poor communication of the metering systems
• In 2020, large scale AMI project to install 55,000 meters was commenced by ZTE. The scope includes to establish Meter Data Control Center, Supply and commission Meter data management system (MDMS) and integrate the existing HES and improve communication of the meters. Additional 12000 meters have been added to the scope	• Meters communicate through the GPRS technology.	• This project covers large power consumers existing at the time of project concept stage, thus all the current large power consumers are not covered in the scope, even after additional proposal of 12000 meters.
• The Project Infrastructure division and the Installation management division are responsible for installation of smart meters in KPLC. • For AMI system, the meter data control center located in Nairobi, with 6 regional meter data centers to cater to all regions.		• As per KPLC, the existing staff in the smart meter data control center have to be trained to leverage the scope of analytics of the AMI system

Table 97: Smart metering Background in KPLC Source: KPLC

g-2) Sample Indicative Service Level Agreement ("SLAs") for monitoring performance of Advance Metering Infrastructure Service Provider ("AMISP")

3.361 As per KPLC, the contract for smart metering does not contain any SLA clause. The team has requested for sharing of indicative AMISP SLAs in any other power utility. The following table provides the indicative SLAs which can be used for monitoring AMISP:

Indicative Service level for meter installation and integration with HES & MDM:

Parameters under SLA	Performance requirement	Penalty
Meter installation SLA		
Installation of smart meters	Milestone based installation of smart meters	5% of total Upfront Capex of cumulative smart meters remaining multiplied by the number of months of delay from specified milestone, capped to a maximum period of 12 (twelve) months. This penalty shall be applicable as per Schedule A: Project Implementation Schedule and shall be levied exclusive of the AMISP service charge (Capex EMI and Opex EMI).

<table>
<tr><th>Parameters under SLA</th><th>Performance requirement</th><th>Penalty</th></tr>
<tr><td></td><td></td><td>The penalty shall be deducted from the invoice raised pertaining to the Upfront Capex cost by the AMISP on achievement of each milestone of Project Implementation schedule.</td></tr>
<tr><td>Installation/Replacement of smart meters in terms of replacement Burnt meter case/ Provide new service connection</td><td>Replace/install the meter within statutory timelines mentioned by DISCOM</td><td>10% of total Upfront Capex cost of cumulative smart meters remaining multiplied by the number of days of delay from specified timelines with no maximum limit.
This penalty shall be deducted from the monthly invoice (AMISP service charge) and monthly penalty shall be capped at 20% of the AMISP monthly fee.
The timeframe for installation/ replacement of smart meters shall be as follows:
<table>
<tr><th>Particular</th><th>Number of Days</th></tr>
<tr><td>Meter installation related to New Service Connection</td><td>4</td></tr>
<tr><td>Meter installation related to replacement of Burnt meter (Post intimation by Utility representative)</td><td>3</td></tr>
<tr><td>Meter installation related to replacement of Defective meter (Post intimation by Utility representative)</td><td>3</td></tr>
</table>
</td></tr>
</table>

Table 98: Indicative Service level for meter installation and integration with HES & MDM

Source: Secondary research **g-3)**

Sample Service level for operational phase of project

Definition of communicating smart meter for the purpose of Opex payment to AMISP:

i. Those meters which transfers daily profile & load survey data for at least 27 days during a 30/31-day month and 24 days during the 27/28-day month.

ii. The meter must transfer instantaneous data for at least 75% Blocks (i.e., 15 minutes block data) per month to HES/ MDM (considering 24 hours availability of Supply).

The total penalties under SLA of this category shall be capped at [20%] of AMISP Monthly Fee.

Operational SLA	Performance Requirement (Averaged over a month)	Penalty (Applicable for Opex EMIs)	SLA Penalty Calculation (For understanding purpose only)
A. Scheduled Tasks			
1. Scheduled daily meter readings			
Previous days (All previous days from the last billing cycle) interval energy and total accumulated energy	From 98% of meters within 24 hours after midnight	Deduction of 0.2% of AMISP Monthly Fee for every 1% or part there of capped at 2% penalty	Maximum Penalty of 2% if action takes place for <88% of meters
2. Scheduled billing profile data for the bill period			
Operational SLA	**Performance Requirement (Averaged over a month)**	**Penalty**	**SLA Penalty Calculation (For understanding purpose only)**
Collection of billing data for the bill period before the next periodic collection is scheduled. Please refer to Annexure J for the billing schedule	98% and above	No penalty	Maximum Penalty shall be 10% of monthly AMISP fees
	≥ 96% & < 98%	Penalty equivalent to 1% of AMISP Monthly fees	
	≥ 94% & < 96%	Penalty equivalent to 2% of Monthly AMISP fees	
	≥ 92% & < 94%	Penalty equivalent to 3% of Monthly AMISP fees	
	≥ 90% & < 92%	Penalty equivalent to 4% of Monthly AMISP fees	
	≥ 85% & < 90%	Penalty equivalent to 10% of Monthly AMISP fees	

	< 85%	i. Penalty equivalent to 10% of Monthly AMISP fees and It will be treated as event of default of SLA.	
Operational SLA	**Performance Requirement (Averaged over a month)**	**Penalty (Applicable for Opex EMIs)**	**SLA Penalty Calculation (For understanding purpose only)**
		ii. There will be additional lumpsum penalty of <amount> on AMISP for such event of default.	
B. Remote Actions / tasks performed by AMI System			
3. For remote connect/disconnect with acknowledgement/ response for selected meters			
Remote connect / disconnect of the AMI meters	Action performed at 90% of meters within 15 minutes	Deduction of 0.5% of AMISP Monthly Fee for every 0.5% or part there of capped at 2.0% penalty	Maximum Penalty of 2.0% if within 15 minutes, delivery takes place for <88.5% of meters
4. For remote connect/disconnect with acknowledgement/ response for selected meters			
Remote connect / disconnect of the AMI meters	Action performed 99.9% of meters within 6 hours	Deduction of 0.5% of AMISP Monthly Fee for every 0.5% or part there of capped at 2.0% penalty	Maximum Penalty of 2.0% if within 6 hours, delivery takes place for <98.4% of meters
C. System Availability			
5. Availability of AMI System per month			
Availability of AMI System per month	≥99.5%	Deduction of 0.3% of AMISP Monthly Fee for every 0.5% or part there of reduction in availability capped at 3.0% penalty	Maximum penalty of 3% shall be deducted when system availability is <95.0%

Table 99: Service level for operational phase
Source: Secondary research

Notes: 1. The total penalties under SLA of this category (Opex payment) shall be capped at [20%] of AMISP Monthly Fee. Here, AMISP monthly fees shall be equal to "Total number of smart meters installed X Monthly AMISP Charges (Capex + Opex)". The cumulative penalty shall not be more than the Performance Bank Guarantee amount submitted by the AMISP.

The deduction shall be computed as AMISP Monthly Fee X penalty % as computed in above table. In case of nonavailability of meter data in the prescribed time limit, the AMISP shall conduct meter reading by the Utility prescribed methodology and technology to cover 100% meter reading of the consumers under project area.

2. Averaged over a month means weighted average performance from meter population over a predefined time interval. For instance,
   a. Assuming on i^{th} day or event, action was done on y_i% of total meters and within stipulated time, data was received from z_i% of y_i% meters. So, the average SLA over the month shall be computed as $\frac{\sum z_i \times y_i}{\sum y_i}$
   b. For system availability, the availability is computed as $\frac{THM-(S1 X 1+S2 X 0.8+S3 X 0.5)}{THM}$; Where THM is total hours in the month when power supply to AMI system is available, S1/S2/S3 is the total non-available hours in Severity Level-1/Level-2/ Level-3. Please refer to Annexure-I for more details on the same.

3. Exclusions: Power Outages, Meter bypass by consumers, Local Temporary/ Permanent disconnection by Utilities, Meter burnt shall be excluded from above SLA calculations.

4. AMISP shall submit AMI generated reports for cases mentioned above based on data available in HES/MDM. For the balance cases, joint visit of AMISP and Utility officials shall be carried out and field inspection report shall be submitted by AMISP to Utility for suitable action.

5. For the purpose of joint visit, AMISP shall put a request to Utility who should allocate manpower for joint visit within 1 working day. In case of non-allocation/ non-availability of manpower from Utility, the report submitted by AMISP shall be final and actionable by Utility.

6. The penalties would be computed on the basis of performance of AMISP for a calendar month.

7. AMISP shall be responsible for collection of billing data for all smart meters which could not be remotely accessed.

8. AMISP shall ensure that the data collection and computation for the purpose of SLA penalties (as mentioned in the following table) should be automated and visualised in Utility Interface.

9. For the purpose of billing, KPLC will read the meters with its own resources, where the meter is working but data is not received at the Specific IP address of MDM due to communication failure or any other reason. No payment shall be made to AMISP for such meters, and a suitable penalty shall be imposed as per SLA. smart meter where the communication fails or any other reason on the part of AMISP, then the AMISP shall ensure that the same meter is communicable in next month; in case of default for two consecutive months, the Utility shall issue a default notice to AMISP and shall consider the case as Event of default for SLA level.

10. In case of remote disconnect, the MDM shall check that zero consumption shall be displayed for next 2 blocks to ascertain the meter is disconnected.

g-4) Experience sharing of smart metering projects of power utilities

Utility / Project	Country	Activity	Benefit
TSSPDCL	India	The objective of the project is to incorporate the functionalities viz, • Advanced Metering Infrastructure (AMI) • Outage Management • Power quality Management • Peak Load Management. • 8800Nos. Single Phase Whole Current RF The meters data is collected by the local Data Concentrator Unit (DCU) by RF Zigbee technology with a range of 100m range	• Automatic meter reading of all consumers. • Mitigation of meter reading errors • Improvement of billing efficiency, reduction of AT & C losses • Remote disconnection & reconnection of services. • Improving reliability and power quality, accurate calculation of reliability indices such • Theft detection • Measurement of reactive power & voltage. • Energy audit at feeder and DTR level
TPDDL	India	The key solutions offered were: • HT meters with modular RF intervention (865-867Mhz) – 250 no's; • Network (Router + Collector) – 70 no's approx.; • Head End Software; • MDM; • Consumer Portal; • Consumer Apps; • Integration of system with SAP, CIS, ADR, OMS, etc.	• 34 MW of power reduction during peak demand. • 99.99% run time data availability achieved. • Zero manual intervention achieved.
BSES	India	Initiative started in FY 2015-16 Installed for controlling theft in high loss areas 4 High loss areas selected with loss > 30% 2200 meters installed	• Loss reduction at high loss area • Real-time data and alerts • Load Management • Outage information • Lower Operation cost • Prompt meter fault detection / alarms • Minimize field visits / manual intervention

Utility / Project	Country	Activity	Benefit
KEPCO	India	• Nuri Technology enabled smart meters • Automatic remote meter reading using digital cellular modems • Head End servers • Metering, Meter Data Management and Network Management Software • Meter data integration services for billing system • EBPP (Electronic Bill Printing & Payment) services for KEPCO customers	o Improved metering and billing services – Nuri AMI provides two-way communication and interval data from every meter in the network o Realized meter reading savings - significant reduction in labor and associated vehicle, fuel and maintenance costs o Reduced customer contact center costs – customer service representatives' use "most recent" meter read for to resolve high bill complaints, complaints about missed or estimated reads, meter access problems, etc. o Load monitoring and forecasting – AMI provides daily inputs to the load forecast. Interval data collected is used for load forecasting
			o Implemented Demand Response programs – through 27 different tariff schemes o Empowered customers to manage their energy use – KEPCO provides meter interval data to its customers to make informed decisions about ways to better manage their energy use o Transmission/distribution/generation planning – accurate usage data is enabling KEPCO to effectively plan and manage systems o Maintained customer privacy – customers objections to having meter readers on their properties is eliminated o Tamper and theft detection – mechanism is in place to detect theft or diversion using tamper alarms and data analyses on meter interval data • High-availability (HA) Network – achieved interruption free service 24 hours/365 days, reduces operational expenses and revenue loss due to service interruptions.

Table 100: Secondary research on smart metering projects of different power utilities

Source: PwC research g-5) Experience sharing of technology implementation of power utilities

Utility / Project	Country	Activity	Benefit experienced
Tata Power Delhi Distribution Ltd. (TPDDL)	India	The key solutions offered: • Identification of business processes for GIS mapping • Integration of Geographic Information System (GIS) with Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Distribution Management System (DMS), Outage Management System (OMS), and electric network modeling (SYME). • Integrating GIS and DMS for their 11 kV network	• Better Asset Management achieved by reduced redundant data and streamlining of asset lifecycle • Improved Operation Management by improvement of outage management , maintenance planning and scheduling and identification of technical losses • Enhanced Commercial Management by Geo-location of customers with the assets, and link each customer to phase, transformer, feeder, and substation, automated customer connection/disconnection and rapid response to power availability requests from high demand consumers
BSES, Delhi	India	Technologies deployed : **Drone technology:** • Usage of high resolution imagery and infra-red thermo scanning- fitted with High Definition camera	**Drone technology benefits:** • Preventive and predictive maintenance of the existing distribution network

Utility / Project	Country	Activity	Benefit experienced
		for visual inspection and an infrared camera for thermal imaging • Accurately mapping assets on the GIS with high accuracy **Block Chain Technology Platform:** • First power distribution company in the country to use blockchain based platform for peer-to-peer (P2P) solar trading • This technology is a transactive layer that utilises close to real-time data from smart meters to facilitate the P2P trading environment and no special apparatus is required.	• Inspection of the overhead lines & equipment, grid-substations, connections, damaged switches, capacitors, detection of theft of equipment and intelligent line profiling using HD videos and images • Timely detection of potential trouble spots and issues for ensuring reliable power supply • Faster patrolling • Hot spot identification • Better preventive maintenance to lesser outages • Power-theft detection • Inspection of roof-top solar installations • Assessment of Vegetation encroachment (around discom infrastructure) **Block Chain Technology Platform benefits:** • Enable consumers to trade power between themselves • Optimal loading of the distribution transformer resulting in increased efficiency and reliability of power supply • The platform will give BSES access to a cost-effective energy alternative during the times of peak demand pricing. • BSES will also benefit by not having to purchase solar energy exported to the grid, gain revenue through transaction fee and wheeling charges.
National smart meter deployment project (Phase-1 from 2012-2014)	Netherlands	• 2 year small-scale Advanced Metering Infrastructure (AMI) rollout for regular replacements, new houses and on customer request • Large scale roll-out for all consumers as phase-2 of the plan	• Energy saving • Savings on call center costs • Lower cost level as a result of the market mechanism (increased switching) • Savings in meter reading costs

Duke Energy – Ohio Smart Grid project	USA	• AMI and Distribution Automation (DA) application • Installation of ~140,000 new Smart Grid meters	• Meter reading : Elimination of most of annual meter reading labour cost • Reduction of theft, resulting in 0.5% increase in overall revenue

Utility / Project	Country	Activity	Benefit experienced
			• Reduction in error due to handheld devices and equipment and avoiding regular meter testing • Acceleration of cash collections • Real time system voltage and control decisions for planning generation requirements
Govt. Owned utilities	Caribbean Islands	• Implementation of an AMI system with theft detection software • Software leveraged data from the meters at premises and transformers to identify 14 different types of meter tampering and illegal taps	• Reduction in power theft : Theft of service losses dropped from 25 percent of generation to 5 percent within 1.5 years • Replacement of underutilized transformers with appropriately sizes
Tampa Electric Company - distributed intelligence program	USA	The components of the distributed intelligence program: • Itron supported its AMI rollout • Grid4C provided a data analytics tool • Three distributed intelligence apps incorporated with the smart meters included theft detection, residence neutral fault detection, meter bypass and detection of high impedance.	• Access to real-time data resulting in actionable information • Discovery of events that are otherwise undetectable by back-office analytics • Timely detection of safety and customer impact issues
Bangalore Electric Supply Co. Ltd. (BESCOM)	India	• Creation of new Information and Communication Technologies (ICT) and Smart Grid Cadre • Initiatives like Restructured Accelerated Power Development and Reforms Program (R-APDRP), Management Information System (MIS), Enumeration of IP sets, Public Grievances Redressal System (PGRS) – consumer empowerment and Smart Grid Pilot projects	• Development of multi-disciplinary team for Smart Grid before project implementation • Specialized IT Cadre to focus on Smart Grid and other ICT initiatives • enhanced employee capacity in Smart Grid

The Duke Energy Smart Grid Demonstration – self healing network	USA	• 100 deployed self-healing networks (as of 2014) • The centralized approach uses the Substation Automation Platform with unique distribution automation (DA) logic software. • The DA controller polls each intelligent electronic device (IED) in the network via Supervisory Control and Data Acquisition (SCADA) to determine the state of the network devices • 91 successful operations (as of 2013) • Automatic restoration schemes	• DA logic software performs the self-healing functions for each network • DA controller analyses the IED information to determine where the fault is located • It also initiates trip and close commands to automatically restore service
Utility / Project	**Country**	**Activity**	**Benefit experienced**
Various other utilities	India	Tripura State Electricity Corporation Ltd. (TSECL): Set of 21 standard analytical reports at the time of project implementation for incorporation by the vendors like daily loss report, daily communication failure report, monthly consumption, etc. Chamundeshwari Electric Supply Corporation Ltd. (CESC), Mysore: Implementation of detailed dashboards with features like load forecasting, consumer profiling, consumption pattern analysis, and theft detection analysis using smart meter & Transformer Monitoring Unit (TMU) data. Ajmer Vidyut Vitran Nigam Ltd. (AVVNL): Preparation of an online web-based dashboard and set of standardized smart meter data report formats to provide real-time data and exception reporting on a user friendly interface; the dashboard was designed to	• Monitor of critical parameters like low power factor, phase imbalance, load exceeding by consumers and provide instant health check of the entire distribution system for optimizing, improving and near future planning

Table 101: Technology implementation of various power utilities
Source: Secondary research

g-6) Experience sharing of loss reduction initiatives of power utilities

Utility / Project	Country	Activity	Benefit
AES Eletropaulo	Brazil	• Residential customers: ✦ Meters encased in plastic and sealed; ✦ Re-metering with electromechanical meters with service drop using bi-concentric coaxial cables. • Commercial customers: ✦ Electronic meters programmed with remote reading, disconnection and to limit consumption in case of nonpayment	• Almost 100% reduction of theft in the pilot area where technology applied. However, up to half of new customers • had difficulty paying their bills in the beginning. • In 2009, non-payment was reduced to 11 % for the pilot area with 8.5% of payment defaults over 30 days.
Eskom	South Africa	• Split Prepayment Meters • Aerial bundled and Coaxial Cables • Automated Remote Metering • Service Drop in Maypole • Locked meter boxes with alarm notification to the utility data centers.	• In the pilot areas, the theft was reduced from 60% to 3-5% and was attributed primarily to the installation of Split Prepayment meters.
Dhaka Electric Supply Company	Bangladesh	• Elevated Metering System with service drop with aerial bundled cables and secure cable connections; • Electronic pre-payment meters with meter seals; • Feeder Level Power Balancing/Macro Metering.	• Since 1996, DESCO reduced overall technical and non technical losses from 47% to 13.4% in 2007 and to 9,55% in 2009.
Meralco	Philippines	• Amnesty schemes • Off-cycle readings & analysis; • Random inspection; • Use of check meters; • Elevated meters (sometimes with high voltage barriers); • Metal casings for meters; and • 24-hour security guards.	• System loss in 2006 was reported at 10.10% and 9.65% in 2007, the first time single digit loss figures had been achieved. This result was largely brought about by increasing the emphasis on improving the timing and quality of the work of apprehending crews. Most of the apprehensions conducted were triggered by the information provided by concerned citizens anonymously through Meralco's website, telephone, and sometimes directly to an email address dedicated to anti-pilferage reports
Tata Power Delhi Distribution Ltd (TPDDL)	India	• Technological interventions -unmanned grids use SCADA through remote ops, GIS to track and mark consumers, Outage management system (OMS) helps generate plan for preventative maintenance to crews • Data Analytics – AMRs with SIM cards to centralized servers for seamless reading and analysis. Developed AMR software in house. • Theft detection – AMR/AMI sends data, logic runs on data – exceptional cases flagged, theft caseworkers dispatched. • Keeps monthly scorecard for employees overseeing different zones – bonuses and base salaries determined by scorecards annually	• Reduced losses from 47% to 10% over 12 years, utility pays dividends, Delhi has some of the lowest tariffs in the country. Since 2008, actual losses were between 4% and 1% below their target. • CAPEX increased while losses decreased until losses were around 10% CAPEX peaked at 43% of operating costs for loss reduction. Reliability then prioritized.

GVCL/ MGVCL/ DGVCL/ UGVCL	India	• 100% metering of customers, feeders and transformers: • Setting-up of Vigilance cells and police stations to contain power theft: GEB had set up one vigilance department	• Reduction in losses. • Reduction in theft of electricity • Improve quality of power supply

Utility / Project	Country	Activity	Benefit
		headed by IPS (Indian Police Service) officer in the rank of Addl. Director General of Police on deputation by the Government of Gujarat. He is designated as "Director of Security & Chief Vigilance Officer" ("DSCVO"). GEB had formulated 74 IC Squads working under Addl. Chief Engineer Vigilance under the control of DSCVO. In the vigilance department, they have formed two types of squads. • This involves network Redesign & CAPEX for installing transformers, and HVDS to improve HT: LT	
MSEDCL	India	• A theft detection drive was launched and corruption cases were handled with a strong hand: MSEDCL launched a theft detection drive in order to improve its collection efficiency. Six dedicated police stations have been established in Maharashtra to handle power theft cases. • Gaothan Feeder Segregation: Under this scheme, MSEDCL is separating the rural feeders that service homes from those that feed agricultural pump sets. • Energy accounting at various levels was taken up: MSEDCL started carrying out feeder wise energy audit ("EA") to obtain feeder wise distribution loss data. MSEDCL started to undertake Monthly Energy Accounting at Division, Feeder and DTC level. • Transformers loading was restricted to 80% level while capex was taken for installation of new transformers: The plan includes setting up of 76,182 km of power distribution lines in order to improve the HT-LT ratio of the distribution network	• Increase in revenue due to reduction in theft cases • Reduction in AT&C losses • Network strengthening

Table 102: Loss reduction initiatives of various power utilities
Source: Secondary research

Annexure 1.1 Governing Regulations

Topic	Description of Regulation in Energy Act No.1 of 2019
New service connection and metering	• The Energy Act 1 of 2019 provides the governing clauses for new consumer acquisition. The Act provides the application and consumer onboarding process, the salient points of which are: • The Act lays down that it is the duty of a distribution licensee, KPLC in this case, to plan and construct the requisite electric supply lines to enable power supply to any applicant. • Post receipt of the application, KPLC should notify the applicant of the terms and conditions, including the required payments, for the applicant to comply prior to commencement of supply. • Forms related new service application can be availed by applicants, free of charge, from KPLC's offices • The licensee shall use a form of contract approved by the Authority which shall set out the rights and responsibilities of the licensee and consumers • In case the electrical installation of the applicant does not meet the requisite conditions, the licensee shall decline to connect supply. In case the supply is connected, the licensee discontinue supply till the defects are rectified
Meter reading and billing	• As per the Energy Act, the metering of supply to consumers shall meter reading shall account for • the amount of electrical energy supplied to the consumer or • the number of hours during which the supply is given, or • the maximum demand taken by the consumer, or • any other quantity or time connected with the supply shall be ascertained by meters of a type approved by the Kenya Bureau of Standards, or determined in a manner agreed upon by the retailer and the consumer. • As per the Energy Act 2019, in case the meter is found defective, the licensee has the authority to determine the quantity of electrical energy supplied to the premises. In this case, the licensee shall recalculate the charges for a maximum period of six months from the date the meter is established to be defective. However, if the consumer had reported any suspected defect in the meter and the licensee fails to examine the meter within 30 days, the licensee shall not be entitled to recover from the consumer any charges for more than thirty days from the date the meter was established to be defective. • In terms of retail tariffs, the licensee may require a consumer to make such account deposit, commensurate with the consumer's estimated electrical energy consumption, before electrical energy is supplied to the premises. The deposit may be periodically revised by the licensee in order to take account of both the level of consumption and of any changes in electrical energy tariffs.
Regulation for revenue collection and arrear management	• As per the Energy Act of 2019, the distribution licensee can disconnect power supply for the premises (or in respect of other premises) in case the consumer fails to pay • charges for consumption of electrical energy or • instalments relating to deferred connection costs However, in case of such charges are referred to KPLC by the consumer for resolution of complaint handling and dispute, disconnection cannot be effected.
Regulation for vigilance and theft control	• As per the Energy Act, KPLC is required to seal he meters with an approved seal bearing the KPLC's distinguishing brand or mark impressed. Where any seal or other apparatus is broken or tampered with without the authority of KPLC, the consumer shall be liable to a penalty upto fifty thousand shillings or imprisonment for upto two years or both. • Where any meter used to register the quantity of electrical energy supplied by KPLC to any consumer is found to be defective through interference by the consumer, KPLC has the right to may determine the reasonable quantity of electrical energy supplied during the period of offence. The charges due from consumer shall be recalculated from the date the meter is established to be tampered: • If any dispute arises under this section as to recalculation of electrical energy consumed by consumer or as to interference with any meter, such dispute shall be referred to the EPRA for resolution.

Topic	Description of Regulation in Energy Act No.1 of 2019
Regulation	• As per the Energy Act 1 of 2019, the Energy and Petroleum Tribunal is entrusted the task of hearing and determining disputes and appeals. Any person not concurring with the decision of the Tribunal may appeal to the High Court within thirty days from the date of the decision or order. • With regard to penalties and compensation for failure and defects in electricity supply, KPLC shall be liable to pay appropriate compensation in case of damage to any person's property, financial loss, loss of life due to negligence or avoidable default by the licensee attributed to failure, poor quality or irregularity of electricity supply, except when caused by third party interference.

Table 103: Governing Regulations
Source: Energy Act No.1 of 2019

1.2 Accuracy class of meters

As per Indian Standards (IS), the meters shall meet the following requirements of Accuracy Class:

Meter type	Meter Accuracy class
Interface Meters Main Meter: At one end of the line between the substations or at both ends of the line between substations	0.2S
Consumer Meters	
Upto 650 Volts Direct Connected	1.0
Upto 650 volts CT Connected	Class 0.5S as per relevant Indian Standard where separate CTs are used Or Class 1.0 as per relevant Indian Standard for terminal less direct connected long current range meters.
Above 650 volts and up to 33 kilo volts	0.5S
Above 33 kilo volts	0.2S

Table 104: Indian standards meter accuracy class requirements Source: Indian Standards

Parameter	KPIs tracked

	Quoted within 14 days

1.3 Connection timelines established by similar power distribution companies

Sl no.	Particular	Timeline
1	**Name of the utility: Telangana State Southern Power Distribution, India**	
1.1	**Processing of application & intimation of relevant charges**	
1.1.1	Requiring only a meter and possible from existing network	2 days
1.1.2	Network expansion / enhancement required	
	LT supply	7 days
	11 kV	15 days
	33 kV	21 days
	EHT	45 days
2	**Release of new connection upon payment of all charges**	
2.1	From existing network	30 days
2.1.2	Network expansion / enhancement required	
	LT supply	30 days
	11 kV	45 days
	33 kV	60 days
	EHT	180 days
2	**Name of the utility : Tata Power Delhi Distribution Limited, India**	
2.1	Connection time: No network augmentation required	8 days (for no RoW cases) 15 days (for RoW required cases)
2.2	Connection time: Network augmentation is required in electrified areas	16 days from the date of payment
2.3	Connection time: Network augmentation is required in unelectrified areas	4 months from the date of payment

Table 105: Power connection timelines
Source: Secondary Research

1.4 Customer charter parameters tracked by KPLC

Parameter	KPIs tracked
Infrastructure parameters	Constructed within 14 days
	Ease of doing Business connectivity timeline
Network parameters	Incidences Resolved within 5 & 8hrs for Urban & Rural respectively
Commercial services & sales parameters	Faulty meter RCCS resolved within 4 days
	Meter replacement worders Resolved within 4 days
	Billing Complaints Resolved within 3 days
Service line Design time	Timelines for quotations and constructions
Reliability	Resolution of breakdowns Rural within 8 hours
	Resolution of breakdowns Urban (Nairobi, Mombasa, Eldoret, Nakuru, Kisumu) within 4hours
Commercial services & sales parameters	Faulty meter RCCS resolution rate
	Meter replacement order resolution rate
	Billing complaints resolution rate

Table 106: Customer charter parameters

Source: KPLC customer charter

E. *Physical metering infrastructure design and standards*

3.362 We made physical visits to select KPLC substations and customers to among other things inspect the status of the physical infrastructure. Our focus in line with our scope of work was on the meters and associated metering infrastructure as this would have a direct bearing on system losses.

3.363 We summarise in the table below the observations that we made during the site visits and our recommendations for KPLC's consideration. We have provided an appendix with the list of substations and customers that we visited including the customers where we observed the exceptions listed in the table below:

Date of Visit	Customer/Substation Name	Meter Number	The Exception Noted	Exception Description	Other Relevant Detail
4/26/2022	Mombasa Maize Millers Ltd	040016116835	Mismatch between Meter PT ratio and Name plate settings	Meter PT Ratio was set at 1/1V contrary to the nameplate setting of 11000V/110V. Meter CT Ratio matched with the nameplate rating.	In the InCMS system the PT was set at 11000V/110V
4/27/2022	Songwoiywo Holdings Limited	01001010179	Inaccurate meter time settings	Date setting was accurate but Time setting was not accurate with meter time set 15 mins ahead	
6/3/2022	Kangatita Tea Factory	040013030802	Big variance between logger and the meter	There has been a significant drop in consumption in the period we have reviewed. See the image of the Customers trend below.	The meter was registering almost 50% less consumption compared to the logger
4/26/2022	Metal Crown Ltd	040016117232	Big variance between the meter and logger data	The customer had a variance of 9.22% with a meter class Cl. 0.2S.	When the meter was compared with a standard portable energy meter, it seemed to be in good working condition
4/6/2022	Accurate Steel Ltd	040016110324	Big variance between the meter and logger data	The customer had a variance of -1.54% between meter and logger. Meter class Cl. 0.2S After the meter was compared with a standard portable energy rai meter, an error of 4% was registered	The meter needs to be checked further. The maximum error is supposed to be 0.4%

Date of Visit	Customer/Substation Name	Meter Number	The Exception Noted	Exception Description	Other Relevant Detail
5/17/2022	Keda Kenya Ceramics	040013031596	One of the largest consumers and still using an AMR Meter Gate was not locked Big variance between the meter and logger data	The customer has a class Cl.1S meter and has a variance of -1.88%.	The meter needs to be checked further. The maximum error is supposed to be 1.5%
4/22/2022	Associated Battery Ltd	040016117229	The smart meter had a big variance when compared with the logger	Meter class Cl. 0.2S and had a variance of -1.40%	The meter needs to be checked further. The maximum error is supposed to be 0.4%
5/13/2022	Consol Glass Kenya Ltd	040016116871	The smart meter had a big variance when compared with the logger	Meter class Cl. 0.2S and had a variance of -3.62%	The meter needs to be checked further. The maximum error is supposed to be 0.4%
5/16/2022	Malplast Industries limited	040010112025	The smart meter had a big variance when compared with the logger	Meter class Cl. 0.2S and had a variance of -4.41%	The meter needs to be checked further. The maximum error is supposed to be 0.4%
5/16/2022	Paras Industries Limited	040016111259	The smart meter had a big variance when compared with the logger	Meter class Cl. 0.2S and had a variance of 1.06%	The meter needs to be checked further. The maximum error is supposed to be 0.4%
5/30/2022	Tarmal wire products	040016110312	The smart meter had a big variance when compared with the logger	Meter class Cl. 0.2S and had a variance of -2.09%	The meter needs to be checked further. The maximum error is supposed to be 0.4%
6/3/2022	James Finlay (K) Ltd	040016110684	The smart meter had a big variance when compared with the logger	Meter class Cl. 0.2S and had a variance of -3.09%	The meter needs to be checked further. The maximum error is supposed to be 0.4%
06/10/2022	Devki Mills Ruiru	040016110311	Delay to grant access to the substation by the customer	We had to wait for over 30 minutes as we awaited the customer to grant us access to the substation	

Date of Visit	Customer/Substation Name	Meter Number	The Exception Noted	Exception Description	Other Relevant Detail
06/10/2022	Devki Mills Athi River	040016110329	Delay to grant access to the substation by the customer Service cables that are dropped underground within the customers premises before being connected to the substation for metering	The staff informed us that we need to inform them earlier if there was any need to visit.	
06/10/2022	Savannah Cement Ltd	040016110283	The substation had overgrown vegetation The gate at the KPLC Side entrance was unlocked	The KPLC side had over gown weeds and vegetation covering the area	
06/10/2022	East Africa Portland Cement	040013031656	The KPLC side of the substation side did not have a door to restrict entry.	The substation is accessible to the customer since there is no door to lock	

Table 107: Observations made during PWC's site visits.
Source: PwC

3.364 We provide the following recommendations for improvements.

Area	Gaps Observed	Recommendations	Timespan
Security of the substations	• Some customer substations were not locked.	• KPLC should keep the customers substations locked at all time to minimise the risk of interference.	• Short term
Physical location and access points to the substations	• Some of the customer substations were customer controlled. KPLC requires authorisation from the customers to access	• KPLC should have an independent access to the substations station without seeking access permission from customer. • This will require the redesign of access points to the substations considering the likely challenges around property acquisition and access rights.	• Medium - long Term
Layout and design of the substations and the metering equipment	• The KPLC underground HT cables passed through customer premises before emerging in the substation	• Cables should drop from the pole through KPLC metering infrastructure before reaching the customer premises	• Long term
Locks and seals of the meter cabinets	• We did not observe major gaps on the metering cabinet seals at the sites that we visited.	• NA	• NA
Placement and settings of the PT and CT transformers and ratios	• We did does not observe gaps except for the settings of PT ratio at Mombasa Maize Millers where meter settings are different from what is in the InCMS system	• NA	• NA
Cabling and wiring	• We did not observe significant gaps. However, some of the cables are ageing and require maintenance	• Regular inspection to check any deterioration of insulation and to assess physical tampering with any of the cables that could point to power theft	• Short term
Physical maintenance of the substation's surroundings	• Some substations had overgrown grass and looked abandoned	• Periodic inspection housekeeping is required.	• Short term
Obsolete, faulty, and decommissioned equipment	• Presence of old, faulty, and decommissioned equipment at some of the substations	• Periodic inspection housekeeping is required.	• Short term
Standards and specifications of the metering equipment	• Higher class meters as discussed in the preceding sections which leads to low metering accuracy. • Use of manual meters that do not transmit data automatically	• KPLC should aim for lower class meters, Class 0.2S at all the metering levels to align with global leading practices • Progression towards smart metering at all levels	• Medium - long Term

Physical inspections	• Lack of periodical or structured physical inspections by the KPLC staff in charge	• KPLC should inspect large customer metering infrastructure every six months as per the KPLC metering manual. Outcomes of the inspections should be documented, and proper records kept.	• Medium - long Term
Area	**Gaps Observed**	**Recommendations**	**Timespan**
		• Regular meter calibration checks and timely rectification necessary	

Table 108: Gaps Observed, Recommendations and Implementation Timespans
Short term (0 – 6 months), Medium term (6-12 months) and Long term (More than 12 months). Source: PwC

3.365 We list the following additional recommendations from the Indian Standard for Testing, evaluation, installation and maintenance of ac electricity meters — code of practice i.e., IS 15707:

i. Location of the meters: In case of indoor installation at consumer premises, the focus of installation practices for tariff meter is preventing misuse and deterring tampering or bypassing of meter by the consumer by having:

a) A visually traceable and joint free incoming cable or shrink-wrapped sealed joints

b) Having clearly visible and accessible seals that can be subjected to easy inspection.

ii. The meters should not be located in inaccessible private areas, or areas that are unsafe, inconvenient or unsuitable for entry by service personnel or an area with uncontrolled or unrestrained access to animals etc. The following shall be considered for selection of site and installation of meters:

a) Metering installation shall be protected from excessive dust and moisture, exposure to direct sunlight, rain and water seepage. The site temperature should be within the limits of O"C to +50"C. It should not be in proximity of machineries, heating devices, equipment generating high vibration or magnetic fields and areas prone to fire and toxic hazards;

b) Additionally, for outdoor installations, the meters shall be protected by appropriate enclosure of level of protection IP 55 and ensuring compliance with above conditions.

iii. HT consumers: The cable terminations should be secured from tampering by sealing, with the seals visible from outside. The routing of the cables should be clearly visible and bare conductors close to termination should be insulated.

iv. in case, a separate CT unit is used, the secondary cables of the CTs shall be run through conduits and well protected from tampering. The CT secondary wires should be as short as possible to keep the burden to a minimum. In order to avoid joints in the main cables, threadthrough arrangement may be used with window type or base mounted CTs

v. In order to prevent tampering with CT corrections, it is recommended to use block CT's that terminate directly on to the meter, thereby making the CT secondary practically inaccessible.

vi. Choice of Tamper Proof Meter Box: There shall be no access to the meters without breaking the sealing arrangement

vii. Following sealing shall be ensured at time of meter installation:

a) Manufacturer's meter seal
b) Service provider's meter seal
c) Terminal cover seal
d) TTB seals (where applicable)

e) CT-VT seals
f) Meter box sea
g) Sealing on cable joint box, etc. There should be at least one seal at all point mentioned above (wherever applicable). The seal shall be tamper proof

viii. A seal management system shall ensure the following:

a) Seals are unique and distinctive for each manufacturer/energy service provider b) Seals are not easily imitable

c) Seals when removed, leave detectable evidence
d) Procurement, stocking, issue, installation and disposal of seals is traceable
e) Traceability should be uniquely identifiable to a responsible individual
f) All numbered seals are traceable to consumers through meter numbers
g) Seals are secured against misuse
h) Sealing punch, when used shall be uniquely identifiable and traceable
i) Seal Management system itself is secure with proper access control.

F. *Summary of shortcomings, implications, and responsible offices*

1.190 In this section we have further summarised the key shortcomings that we observed, the possible implications, the responsible offices, and our recommendations. The detailed findings and recommendations are set out in the preceding sections.

S/No.	Shortcomings	Implication	Responsible Offices/Department/Directorates	Recommendations
1.	• Unusual losses and consumption anomalies by some large customers as set out under Section C above	• Possible commercial losses	• General Manager, Commercial Services	• Investigate the cases highlighted in the Report further including interviews with the customers. This will help conclude on the culpability of specific officers that were responsible for the losses. • Broaden the scope of review/investigation beyond the sample customers that PwC reviewed
2.	• 19% of large consumers do not have smart meters. Some of these were still large customers when the smart metering project began.	• Inability to detect malpractices such as meter bypasses or other types of interventions that would otherwise be reported by the smart meters.	• General Manager, Commercial Services	• Install smart meters at all large customers. • Investigate consumption exceptions that may arise after installation of smart meters. • Where exceptions are noted and it is likely that the lack of smart meters allowed the anomalies to persist, investigate whether the non-installation of the meters was deliberate and if so, assess culpability of the officers involved.
3.	• Reduced customer vigilance after the installation of smart and pre-paid meters since there is no longer need to visit customer sites for meter readings.	• Inability to monitor, deter and detect system losses	• General Manager, Commercial Services	• Redesign the vigilance and inspection mechanisms to reflect the operating procedures under smart and pre-paid meters as recommended in this report.

4.	• Rapid growth in the customer base in the last 10 years (70%) not matched with proportionate internal capacity enhancement of the field inspection teams.	• Inability to monitor, deter and detect system losses	• The Board and Senior Management	• Enhance the internal capacity to match the increased customer base by way of personnel and tools

5.	• Overall lack of ownership, accountability, dedicated resources, and a coordinated approach in the accounting of energy.	• Inability to prevent, detect and mitigate system losses • Suboptimal allocation of resources	• The Board • General Manager, Commercial Services • General Manager Network Management • General Manager Power Planning and Purchases	• Enhance governance, ownership, and accountability in the energy accounting at by the technical and commercial teams. • Prioritize system losses reduction at the Board and Senior Management levels
6.	• Widespread metering gaps at generation, transmission, distribution and at customer sites. Including but not limited to missing meters, miscalibrated meters etc.	• Inability to establish the sections of the grid where system losses occur, which would inform targeted loss reduction initiatives • Inability to detect malpractices such meter bypasses	• General Manager, Commercial Services • General Manager Network Management • General Manager Power Planning and Purchases	• Remediate the metering gaps – install and calibrate the meters • Investigate the exceptions that may occur after installation of the meters
7.	• Possible miscalculation of losses due to the use of outdated loss study reports, partial simulations, and arithmetical errors. • Absence of energy balance calculation on some sections of the grid	• Inability to establish the section of the grid where system losses occur, which would inform targeted loss reduction initiatives	• General Manager, Commercial Services • General Manager Network Management • General Manager Power Planning and Purchases	• Comprehensive and accurate energy balances across the entire grid • Investigation of exceptions that may occur after the energy balance analysis

8.	• Limited automation and use of an intelligencebased approach in the management of system losses.	• Inability to effectively and efficiently manage system losses	• General Manager, Commercial Services • General Manager Network Management • General Manager Power Planning and Purchases	• Automation and use of an intelligencebased approach in the identification and management of losses. • This ought to start with the tools that KPLC already has at its disposal e.g. smart meters, the SCADA system etc.
9.	Lack of follow through and conclusive investigations in the following areas:	• Inability to deter and detect system losses and therefore failure to	• General Manager, Commercial Services	• Institute investigation and enforcement mechanisms for issues raised by the internal audit teams, usage variations in
	• Alerts raised by the customer smart meters • Customer power usage exception reports • Issues noted during internal audits • Recommendations in the 2015 Tetra-Tech Energy Losses Study Report	contain the increasing losses		• exception reports, alerts generated by smart meters etc. Constitute a committee with the requisite powers and mandate to oversee the implementation of the recommendations in this report as well as other reports that touch on power losses.

G. *Conclusion*

3.366 As we have discussed, our review highlighted several instances of unusual power consumption patterns by some large consumers that KPLC should review further. This is in addition to the process and standards improvement opportunities that we have summarised in section D above.

3.367 Collectively, these additional areas and procedures that we propose will enable KPLC gain a better understanding of the system losses, where specifically the losses occur in the grid and inform the interventions that KPLC would need to make to reduce the losses.

3.368 In making our recommendations we have included in section D ii) and in section E tentative timeliness based on our understanding of the nature of the issues. We recommend that KPLC evaluates the recommendations further including the timelines with a view to come up with a revised work-plan that will inform the implementation strategy.

3.369 KPLC should consider implementation of the recommendations for improvement in efficiency of the commercial processes based on the improvement opportunities identified under the umbrella of short term, medium term and long term.

3.370 The commercial processes cover the entire value chain i.e., metering, consumer indexing, meter reading, billing, revenue collection, arrear management, commercial monitoring- vigilance, customer care and energy accounting.

3.371 In the areas of consumer indexing, metering and energy accounting, KPLC should conduct feeder wise consumer indexing and metering, at sub-station and feeder level (at 66 kV, 33 kV and 11 kV level) and border metering at the county level. In order to monitor the commercial processes in an efficient manner, feeder wise monitoring should be done by the Corporate office. To achieve this target, effective consumer indexing or tagging with respective distribution transformer and feeder should be done on a regular basis so that new consumers can also be included in the network. KPLC should also plan to cover all the large power consumers under the smart metering program.

3.372 KPLC should consider streamlining of meter reading of LT, LT high value and HT (large power) consumers. KPLC should implement the photo-based meter reading for LT postpaid consumers and machine-based meter reading through meter reading instrument for HT consumers. This will increase the meter reading efficiency and reduce manual interventions.

3.373 KPLC should embrace data analytics on metering and billing data; this will inform targeted verification of areas and consumers with a high risk of revenue leakage. A MIS dashboard at Corporate level should be considered to cover all the commercial and operational parameters for monitoring of performance of operational areas; the dashboard ought to feature consumer pattern analysis, arrear management, tracking lifecycle of inspection and feeder wise energy balance for effective energy accounting.

3.374 To optimize the performance of the manpower deployed, KPLC should consider critical Key Performance Indicators (Revenue loss, Capex initiatives such as like converting slums LT network to MV/HT or AB cables network to deter interference, metering of unmetered streetlights etc.) for the operational staff.

3.375 It is also essential to streamline the implementation of Smart metering program, and the use of the data generated by the smart meters through data analytics.

3.376 In future, KPLC should design an effective loss reduction plan and monitor the implementation of identified tasks for loss reduction and efficiency improvement; a department should be constituted in this regard. KPCL should also assess the digital immersion in various commercial and operational processes in terms of preparation of an IT roadmap so that effective utilization of IT tools can be done for overall efficiency improvement of the utility.

Areas of further work

4. Areas of further work

4.1 In this section we set out areas where KPLC ought to consider further work based on the review that we carried out. This covers both the areas we were not able to comprehensively review due to time constraints as highlighted in the limitations section of this Report, and areas that were not in our scope but are of interest to KPLC in reducing the system losses.

4.2 Collectively, these additional areas and procedures that we propose will enable KPLC gain a better understanding of the system losses, where the losses occur in the grid and inform the interventions that KPLC would need to make to reduce the losses.

A. *Overall loss assessment*

4.3 Investigate the cause of the system losses increase between 2017/2018 and 2018/2019: Our analysis showed that in this period the system losses grew by about 5%, from 18% to 23%. Post this period, the losses remained relatively constant up until recently when they started reducing.

4.4 We further observed that there were some major projects that were ongoing at the time that could have impacted the system losses. These included the rapid expansion of the grid through rural electrification projects, the commissioning of the two largest power generation plants, LTWP and Olkaria V. KPLC should consider undertaking further investigations on these and other developments of interest in that period to assess if they may have contributed to the increase of system losses.

4.5 Benchmark the losses against similar power distributors: The limited benchmarking that we carried showed that the losses that KPLC reported in the transmission and distribution networks are higher than the losses contained in a World Bank benchmark study of 1982. When compared to power distribution companies in India, we observed a similar trend. To augment these observations, KPLC should consider a further benchmarking with power distribution companies that operate in a similar environment, in Africa and beyond. Such a study should also aim to establish the loss reduction strategies adopted by other power distribution companies and the lessons that KPLC could learn from them.

B. *Loss assessment in the generation and transmission*

4.6 **Separation of commercial and technical losses**: In the current KPLC losses calculation methodology, the losses between the generation plants and the transmission substations are assumed to be technical losses in totality. However, it is probable that some of these losses include commercial losses attributable to large consumers connected to the transmission network. Assessing and quantifying commercial losses that may exist in the transmission network will enable KPLC recover from the respective customers and to adopt suitable control measures.

4.7 **In-depth assessment of the power that leaves the transmission network into the distribution network:** We observed in some instances there are no meters at the transmission substations, the meters are faulty, or the meter readings are not consistently read, or KPLC does not have visibility of the meters since the substations are under KETRACO etc. This limits the accuracy of the KPLC calculations of the power that gets into the distribution network. A more accurate assessment of the power that gets into the distribution network will give KPLC an accurate view of the losses in the transmission and distribution networks.

4.8 **Breakdown of the transmission losses line by line:** At the moment, KPLC does not breakdown the losses to the transmission line level. Instead, the transmission losses are calculated in bulk as a net of the gross power purchases and the power that gets into the distribution network. A line-byline loss breakdown will enable KPLC focus the loss reduction initiatives on the transmission lines that have the highest losses.

We noted that KPLC has already made an investment in transmission line meters which are already installed although these have not been regularly calibrated and well maintained. KPLC can therefore invest in the calibration and maintenance of the existing meters and utilize them in establishing transmission losses by line and to obtain the maximum value from the investment in transmission line meters.

C. *Loss assessment in the distribution network*

4.9 Breakdown of the losses at the counties levels: KPLC has broken down the system losses up to the regional level. It would be useful to break down the losses at the county level to facilitate investigation of the counties with the highest losses. This will drive accountability of the power and losses at the counties level. Some of the regional and counties teams we engaged expressed to us that it is difficult to take ownership and accountability for the losses since the power that gets into their respective counties, and the losses, are unknown.

4.10 Investigation of the feeder circuits with high losses: As set out under section 3 C (iii) of this Report, our analysis showed that some feeders have high unexplained losses. KPLC should prioritize investigating the feeders with high losses and take the appropriate remedial actions. They will need records of load transfer records between feeders to assist them

4.11 Investigation of the power consumption discrepancies that we observed on some customers: We have outlined the specific customers under Section C "Loss assessment in the distribution network" of this Report, but the discrepancies fall into the following broad categories:

- Discrepancies between the consumption metered by KPLC and our independent consumption measurement. We carried out independent measurements on 32 customer sites and of these 12.5% were outside the 3% limit set by KPLC for the removal of meter for further investigation. 56% of the sites were higher than 1% which is the highest error of the meters deployed to the KPLC Network. The potential annual loss is KES 135 Million.

- Customers who consistently purchased suspiciously low amount tokens. We noted 200,761 cases involving 52,596 unique mobile numbers where customers purchased units worth KES 1 in March 2022 for 48,819 unique meters.

- Customers with outstanding debts. In this category we observed that there are 750 customers with 676 accounts that have debts that exceed 90 days, among these accounts 550 are active accounts and still connected to power. KPLC's policy on arrears management process dictates that bills are given a credit period /disconnection notice which is 14 days from date of billing after which power is disconnected, if the account is not paid for within 90days upon disconnection, the account is terminated and deposit offset. Upon further analysis we learnt that corporate accounts are exempted from the 14-day debt reconnection and 90-day termination policy. These accounts comprise of the largest debt share.

- Discrepancies in large customer bills after our re-computation. We independently recomputed the bills for each billing cycle in the review period and identified 1,697 accounts whose bills had variances between KPLC bills and independently recomputed bills with the variances exceeding KES 10,000. The potential average annual loss was about KES 102 million.

Persons Interviewed/Consulted

No	Abbrev.	Full Name	Designation	Date
1	Eng Angira	Angira, Leo Eng	2nd Assistant Engineer	25 March 2022
2	Eng Barasa	Barasa, Stanley Eng	Manager, Technical Audit	24 March 2022
3	Mr Chebaibai	Chebaibai, Eric Mr	Customer Service Officer I	13 April 2022
4	Mr Cheruiyot	Cheruiyot, Charles Mr	General Manager, Internal Audit	28 March 2022
5	Eng Chokera	Chokera, Joshua Eng	3rd Assistant Superintendent	25 March 2022
6	Ms Christine	Christine, Tum Ms	Chief Officer, Market Research & Corres	14 April 2022
7	Mr Ihuthia	Ihuthia, John Mr	Ag General Manager Power Planning and Purchases	15 June 2022
8	Eng Jamwa	Jamwa, Peter Eng	Head of Technical Services, South Nyanza	14 June 2022
9	Eng Jelagat	Jelagat, Metrine Rotich Eng.	1st Assistant Engineer	07 June 2022
10	Ms Kalungu	Kalungu, Cecilia Ms	GM HR and Administration	17 June 2022
11	Ms Kanini	Kanini, Margret Ms	Manager Sales	13 April 2022
12	Eng Kapsowe	Kapsowe Henry Eng	Chief Engineer, KPLC Off-grid Power Stations	26 May 2022
13	Mr Khaluoch	Khaluoch, Okoth Mr	Chief Internal Auditor	24 March 2022
14	Dr Kinyua	Kinyua, John Dr	Chief Internal Auditor, General Audit	24 March 2022
15	Eng Kiplimo	Kiplimo, Brian Eng	4th Assistant Engineer	Various consultations
16	Eng Machasio	Machasio, Aggrey J Eng	General Manager, Infrastructure Development	16 June 2022
17	Ms Maina	Maina, Beatrice Muthoni Ms	SCADA/EMS Engineer, National Control Centre	07 June 2022
18	Mr Muli	Muli, Geoffrey Mr	Ag. Managing Director & CEO	25 March 2022
19	Eng Mwangi	Mwangi, Paul Eng	Ag GM Network Management	25 March 2022

No	Abbrev.	Full Name	Designation	Date
20	Eng Charles	Mwaura, Charles Eng	General Manager Network Management	16 June 2022
21	Ms Namu	Namu, Catherine Ms	Customer Service Officer I	13 April 2022
22	Mr Ndegwa	Ndegwa, James Mr	2nd Assistant Superintendent	13 April 2022
23	Ms Njau	Njau, Mary Ms	2nd Assistant Engineer	21 April 2022
24	Eng Njoroge	Njoroge, Joseph Eng	3rd Assistant Engineer	Various consultations
25	Eng Obiero	Obiero, Dan Eng	Regional Manager, South Nyanza	14 June 2022
26	Eng Oduor	Oduor, Rosemary Eng	General Manager, Commercial Services	15 June 2022
27	Mr Ogalo	Ogalo, Kennedy Sunga Mr	Manager, Power System Design & Development	28 June 2022
28	Ms Ombuya	Ombuya, Susan Ms	Chief Engineer, Energy Purchase	27 May 2022
29	Mr Owiti	Owiti, Awour Mr	GM Legal Regulatory Affairs	04 April 2022
30	Ms Siele	Siele, Cynthia Ms	Manager, Employee Resourcing	24 March 2022
31	Ms Waceke	Waceke, Eunice Mbugua Ms	Manager, Customer Experience	14 April 2022
32	Mr Wainaina	Wainaina, James Mr	Ag. Manager, Commercial Cycle	13 April 2022
33	Mr Wambua	Wambua, Peter Mr	Acting GM Commercial and Sales	14 April 2022
34	Mr Wanyonyi	Wanyonyi, Peter Mr	Ag. Chief Engineer, Installations Management	Various consultations
35	Ms Zilpa	Zilpa, Ayara Ms	Customer Experience Officer I	14 April 2022

Table 2: Persons consulted/interviewed

Conclusion and next steps

5. Conclusion and next steps

5.1 As we have set out in the various sections of this report, our work showed anomalies and discrepancies that point to irregularities and or lax power accounting processes at KPLC.

5.2 We recommend that KPLC progresses the conclusion of the investigations to a logical conclusion with an aim of recovery from concerned customers and administrative action on the staff who were responsible and or culpable.

5.3 KPLC should further consider a more comprehensive losses assessment at all levels of the grid. The limited analysis we carried out showed gaps that could distort system losses calculations, and the sections of the grid where the losses occur. An in-depth assessment would be useful in informing KPLC the areas where to prioritise efforts and resources for the maximum benefit by way of loss reduction.

5.4 We have further made recommendations on the process improvement opportunities that exist to enhance the power accounting processes. KPLC should consider these recommendations and develop a prioritised implementation roadmap. It is appreciated that some of the recommendations are long-term in nature and will require significant investments therefore the need for a prioritised implementation roadmap.

5.5 The implementation of the recommendations, together with the further assessment of the losses, ought to be led by a dedicated team for accountability and in the interest of ensuring there is progress. One of the factors we observed that contributed to the unsuccessful implementation of the loss reduction initiatives in the past was the lack of a dedicated, structured and well-resourced team.

Appendices

6. *Listing of Appendices*

Appendix	Details
1	Notes from our meeting with Ms Kalungu
2	Summary of monthly transmission loss calculations from July 2018 – March 2022 Mrep reports
3	Notes from our meeting with Eng Mwangi
4	Meeting notes with Eng Ihuthia
5	Internal Audit Report dated 23 August 2021
6	Email from Chief Engineer, Energy Purchases on high variances between check meter and main meter
7	Regional energy report from July 2020 – March 2022
8	Meeting notes of meeting with the SCADA team
9	Meeting notes of meeting with the network team
10	Notes from our meeting with Eng Mwaura
11	Meeting notes for meeting with South Nyanza regional team
12	Extract of 2015 Tetra Tec report.
13	Notes from our meeting with Eng Oduor.
14	KPLC's Technical Audit Report No. 06 - 2019/2020
15	Paper to the KPLC Executive Committee titled "KPLC Metering Roadmap"
16	List of 16 Large power customers in initial list of customers to be retrofitted with smart meters that were not retrofitted.
17	KPLC Internal Audit report No RA-2020/2021-4
18	Breakdown of feeder losses
19	Feeders with high losses
20	Customer bill reconciliation and debt aging procedures.
21	Flow chart for TOU final 040818
22	Monthly Pass-Through Rates
23	Revised yellow book
24	Energy consumption threshold calculation
25	List of documents not provided
26	Loss status & Loss Reduction strategies 2021/22

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