BLOCKCHAIN TECHNOLOGY AND OPERATIONAL EFFICIENCY IN KENYA'S POWER SECTOR

BY

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DECLARATION

Student Declaration

This research project is my own original work and has never been presented for consideration in any other University.

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Supervisor Declaration

This research project has been submitted for examination with my approval as the University Supervisor.

Name: Professor X.N. Iraki, Faculty of Business & Management Sciences

Signature: X N Iraki ……………………………   Date: May 3, 2022 ………………………

DEDICATION

My special dedication goes to my Parents, *Joseph Atinda* & *Phelesia Serwa*

Wife

Rabecca S. Kamandi

Children

Ephraim Atinda, Yasmin Atinda

You were the motivation behind this noble course

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I give all thanks to Yahweh, the Almighty God, for His infinite mercy and guidance in the completion of this project work. 'Praise the LORD, my soul; all my inmost being, praise his holy name. (Psalm 103:1)

My sincere gratitude and appreciation go to my supervisor Prof. XN Iraki, who took me through topic formulation, proposal development and the final project report. Thanks for your guidance, patience, and constructive critics throughout the project phases. I indeed learnt from one of the best management minds.

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My sincere best of luck and prayers be with you all.

Euggine Atinda

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ABSTRACT

The Kenyan power sector has proven to be a success story, especially in the global renewable energy market. This has been attributed to the strong Government support and long-term partnership with IPP and fintech companies. In addition, there is a predictable and strong enabling market for innovative off-grid solutions. However, despite these great initiatives by all power industry players, the sector's operational efficiency and power cost are not reflecting the efforts made so far. The study investigated how blockchains or distributed ledger technology, through its transparent, tamper-proof, and secure systems, could streamline and take Kenya from good to great across its power generation, transmission, distribution, and regulation processes. The study attempted to scope the operational efficiency of governmental entities (MoE, EPRA, REA), the national utilities (KENGEN, KPLC, KETRACO), the IPP (Orpower), the fintech (M-kopa) and end-users. The study was guided by the following objectives: to map out potential applications of blockchains in the Kenyan power sector, to investigate the impact of blockchains on operational efficiency and to determine the constraints facing the adoption of distributed ledger technology by the Kenyan power sector. The study adopted a descriptive research design where a sample size of 12 respondents consisting of departmental heads, business unit managers, senior engineers, ICT offers and general management professionals. The study observed that remote working had been partially adopted by most organizations. This minimized face-to-face meetings, interview guides were therefore administered via telephone calls and video conferences. Content analysis was applied to analyze objectively, interpret, and discuss the collected data. The findings from research established that blockchain is relevant for direct application in the Kenyan power sector, ranging from the imminent P2P trading platforms, digitization by IoT, decentralized trading platforms and E-mobility. For every application, the study identified the potential drawbacks and possible solutions to be overcome by Kenya's power sector mainstream.

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LIST OF ABBREVIATIONS AND SYNONYMS

ACEEE	American Council for an Energy-Efficient Economy
EPRA	Energy and Petroleum Regulatory Authority
GDC	Geothermal Development Company
GSM	Global System for Mobile Communications
GW	Giga Watts
IBM	International Business Machines Corporation
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IPP	Independent Power Producer
KEMSA	Kenya Medical Supplies Authority
KENGEN	Kenya Electricity Generating Company
KETRACO	Kenya Electricity Transmission Company
KPLC	KPLC and Lighting Company
LCPDP	Least Cost Power Development Plan
M2M	Machine-to-Machine
MW	Mega Watts
NLC	National Land Commission
P2P	Peer-to-Peer
PPA	Power Purchase Agreements
REA	Rural Electrification Authority
REREC	Rural Electrification & Renewable Energy Corporation
ROE	Return on Equity
SCADA	Supervisory Control and Data Acquisition
SME	Small to Medium-sized Enterprise
USAID	United States Agency for International Development

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CHAPTER 1 : INTRODUCTION

1.1 Background of the Study

This chapter contains the background of the proposed study, key concepts, problem statement, and research objectives. The study analyzes the potential of blockchain applications in Kenya's power sector. Blockchain technology is a distributed and shared digital data structure encompassing a constantly growing log of transactions organized chronologically. This may be in the monetary form of Cryptocurrencies such as Bitcoin or non-monetary such as Smart Contracts that are executed automatically given predefined conditions are met. According to Tapscott (2016), Blockchains function as a decentralized database containing a dynamic list of transactions that are time bound, distributed, unchangeable and tied to initial blocks. These transactions are verifiable via computer programs at every interval and encrypted such that any modifications would need reconfiguration of all the intervals, which is both a computationally and structurally hard task. However, advanced recent blockchain characters such as Ethereum have significantly reduced the computational struggle by increasing scalability and enabling blockchain technology to potentially grow into the fundamental component of all future digital processes (Boroujerdi & Wolf, 2015). One potential area of application is in the power sector.

The global power sector is confronted with three main challenges: the ability to meet ever-increasing power demand, climate change balance, and increased urbanization. These extremely dynamic environments, coupled with increased investments by most governments in the energy sector to meet this market demand, presuppose the need for transparency and the adoption of strategies that lead to the availability of affordable and sustainable power (Bouttes, 2011).

Notwithstanding the noticeable progress made by the Kenyan government through last-mile connectivity, many citizens still have no access to electricity, and those already connected suffer impoverished quality as low reliability continues to strangle their desires for economic growth. Comparable to many African power distributors, the KPLC Company is bedeviled with a profitless customer base, poor management and an agency problem in accessibility and profitability (Mutiso & Jay, 2018).

Strengthening transparency in Kenya's power sector supply chain process can enhance operation efficiency among all the key players. In Kenya, the main players include the power generation sector (KENGEN), transmission sector (KETRACO), distribution sector (KPLC), and finally, regulator (EPRA). Evidence-based management control systems and audits among the four players would increase the accuracy and efficacy in decision-making by each sector, thereby improving accountability and productivity too. One proposed tool to address this is blockchains.

Blockchain technology provides a publicly accessible database that accommodates a continuously increasing log of chronological transactions within each power sector. This would thereof predict in advance and manage the overdraft costs without transferring them directly to consumers' bills before the end of each financial period. For instance, smart metering and smart contracts between the customer and power distributor (KPLC) can lead to automated billing, which would increase revenue to the company through the provision of diverse collection points such as those used by energy micropayments and locally known as M-kopa's pay-as-you-go platforms (Merlinda, 2019). According to various schools of thought, creativity and innovation are critical in the realization of competitive advantage by Kenya's power sector (Morris, 2007). They reinforce the acquisition of automation gained from blockchain technology to enhance creativity and innovation in managing the power sector (Olivas-Lujan, 2013). According to Andoni (2019), there needs to be a simultaneous change in sales practices congruent with consumers' power profiles, customer preferences, and climatic change concerns. A combination of blockchain and artificial intelligence, for instance, machine learning, can enable KPLC to correctly pinpoint consumer power demands and thereby provide customized value-added power provision. This will significantly reduce power surges and unplanned power blackouts.

The power regulator (EPRA) was created by an Act of parliament (Energy Act,2019) to regulate, monitor, and supervise both the upstream and downstream flow of the power sector (Authority, 2021). It remains the only regulator for electricity, renewable energy, and petroleum sources of power in Kenya, thereby acting as a direct link to the customer in terms of the cost of all the sources of energy listed. Blockchains could make the regulators' work easier. This study is about the potential of blockchain technology in Kenya's power sector and how it can improve operational efficiency and reduce the cost of power to the common Kenyan Citizens. Cheap power is the basis of industrialization (Wrigley, 2013).

1.1.1 Blockchain Technology

Merlinda (2019) depicts blockchain as a mutual and distributed data ledger that safely stores digitized transactions and events in a decentralized point of authority. The evolution in blockchain technology now enables the creation of unique blocks that are checksum and cryptographically related to preceding blocks that constitute a bond of transactions that defines the sequential arrangement of future activities. This enables the realization of automated and executable smart contracts within peer-to-peer (P2P) platforms. Alternatively, blockchains can be viewed as databases that authorize many users to edit different ledgers simultaneously. This eventually results in numerous chained versions that allow users to easily reach a consensus on the accepted state of the ledger.

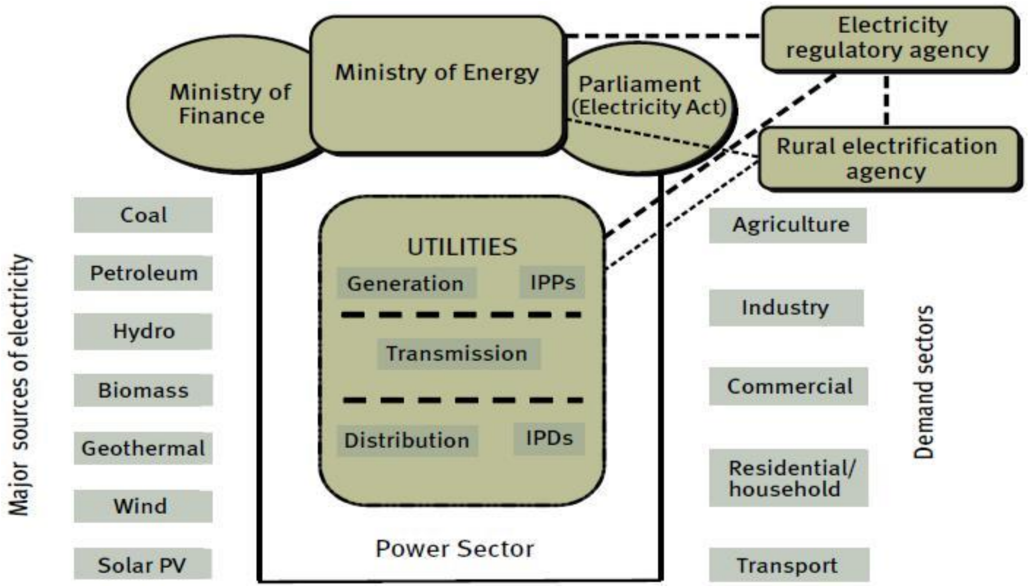
As Bisoux (2018) demonstrated, given blockchain security advancement, each attached block cannot be edited or penetrated. In addition, the ledger is an open-wide document that records transactions among different entities in a more gainful and open technique. The blockchains run on digital frameworks whereby data transmission is based on the cryptocurrency domain, which is like copying digital data from one storage location to another. Consequently, this brings the challenge based on the reality that technology must always ensure no dual spending arises, but coins are spent only once. Traditionally, this could be achieved by using a central point of authority such as the Central Bank of Kenya, which plays the role of a trusted referee in a game between transacting entities and the auditing entity. The central authority also must ensure that in case multiple entities demand to update the ledger simultaneously, concurrency control and consolidation are correctly reported to the ledger. Unfortunately, it is common that the central management system may not work as expected since it has inherent intermediary levies and demands that the system users trust another third party to manage the system.

The main objective of blockchain technologies is to eliminate the need for such intermediaries and restore a distributed network of digital players working harmoniously to verify transactions at a high level of integrity. Conversely to a centralized system, in a decentralized system, transparency is enhanced since every player in the blockchain network owns a copy of the ledger, thereby ensuring easy access to and verification of historic transactions (Merlinda, 2019).

Blockchains can also be analyzed according to their advancement aspirations; they can be general or specific objective blockchains. For instance, Ethereum is devised to contain a wide range of application cases, while Bitcoin is created explicitly for cryptocurrency operations. Additionally, in the context of administration and obligation procedures of the system functionality, blockchain classification can either be open or closed source. The open-sourced blockchain is accessible to all network players and can enjoy the advantages of boundless and honest peer assessment, public deliberation, and public participation in making decisions. On the other hand, closed source blockchains work equivalently to private entities, where every change in the regulations of engagement is determined privately.

Unfortunately, a single blockchain solution design cannot support all functionalities and players; hence, this calls for a hybrid system approach that combines private and public blockchains with diverse degrees of centralization. The management of any organization should analyze and decide what works best for them since the resulting system architecture and harmonized formula used in the system environment directly contribute to the key performance parameters such as efficiency, speed, and scalability of resource utilization within the organization (Bisoux,2018).

1.1.2 Operational Efficiency



(Ajibade, Lasisi, Utun, Ojo, Adewumi, Babatola, 2017)

Operational efficiency refers to the correlation between an entity's output and input, which, when sound, enables the organizations to minimize unwanted expenditures while maximizing revenue. This is what most businesses in the power sector must strive to achieve, that is, to produce superior products at scale with the minimum resources possible (ActivTrak,2021). According to Porter (1996), a need exists to marry an organization's strategy to operational efficiency exists. Therefore, when developing a strategy, the top management should focus on the core competencies and critical success factors within their entity. This will ensure a sustainable competitive advantage by identification of the weaknesses that need immediate attention and are attractive to competitors. The growth in a competitive edge in the Kenyan power sector, especially between renewable and nonrenewable energy, has forced most energy firms to develop new approaches in an operational performance evaluation that resonates with the market behavior (Kuria, 2013).

Consequently, operational efficiency is never considered standalone but always coupled with operational effectiveness. While efficiency evaluation measures the production performance in operation, effectiveness measures the capacity of each player in the power sector to adjust its capital inputs to influence the firm's output in meeting the energy demand. Therefore, the efficacy measure that is achieved by considering both efficiency and effectiveness enables evaluation of the operational performance of the power sectors as they strive to respond accurately to market behavior and their operations management goals (Ke Wang & Lee, 2008).

Ideally, operational efficiency can be theoretically measured using developed design laboratory models. However, it may be very challenging to accurately identify sources of inefficiencies due to the variation between observed performance and ideal performance. This challenge has been considered by Mohamad & Abbasi (2014) in their definition of Relative Operational Efficiency (ROE) as the correlation between actual throughput and the observed throughput.

According to Wang & Lee (2008), the current competitive electricity market has forced power industry players to adopt advanced efficiency evaluation models that resonate with market behavior in operations management. To combat the main challenges of achieving energy conservation, carbon emission control and sustainable development, there is a need to promote operational performance management in the power sector. Traditionally, the operational efficiency measures used could not accurately differentiate between sales outcome from production efficiency and, therefore, inaccurate in measuring the operational performance of power generation firms in relation to operations performance targets such as electricity sales promotion. The measure of effectiveness relates to the capacity of power generators to strategically adjust their input resources always to ensure that their power capacity relates to the electricity demand. Currently, to measure operational efficiency, most power sector firms apply the accepted data envelopment analysis method to evaluate operational efficiency and effectiveness. Based on the outcome of the evaluation, alternative operational performance improvement strategies such as input resource saving are implemented. Therefore, to achieve effectiveness, any increased capacity of power generation and transmission should be reflected by improved electricity sales (Ke Wang & Lee,2018).

1.1.3 Blockchain Technology and Operational Efficiency

The fundamentally appreciated application of blockchains and Ethereum is Bitcoin, which remains the first cryptocurrency in the world developed in 2009 after the original white paper by Nakamoto (2009). Bitcoin, a currency that only allows electronic transactions, promotes a purely online peer-to-peer version of cashflows between unknown trading parties without using any financial institutions. Digital transactions are only controlled by computer networks that harmoniously work using cryptography to ensure the security of all assets. Additionally, this technology provides protection against double-spending through digital signatures in the form of networked timestamps by enabling continuous hashing of all the transactions. Consequently, this forms a chain of records that cannot be changed without proof of work (Nakamoto, 2009).

Supply Chain Management is another area that would benefit from blockchains. According to Insider (2020), supply chain management directly benefits from blockchain's invariable ledger that solves the puzzle of real-time tracking of commodities throughout the supply chain process. Blockchain provides multiple options for different traders during logistics through the application of entries by queuing up events and transactions within the supply chain, thereby enhancing the operational efficiency of logistics companies through organized, dynamic data tracking and application (Insider,2020).

Sales and marketing could also benefit from blockchains. For instance, the transformation of sales processes depending on the specific customer's power demand profiles, client preferences and global warming concerns. Furthermore, blockchain technology combined with artificial intelligence and machine learning could accurately depict customers' power demand patterns, thereby enabling the development of tailor-made solutions to their energy demands (Christoph, Andreas, Philipp & Jens, 2016).

Power sector decision-makers and energy utility organizations in Germany have claimed that the application of blockchains in the power sector could likely quick-fix a huge chunk of operational inefficiencies in the energy sector (Christoph, Andreas, Philipp & Jens, 2016). According to the German Energy Agency, blockchain technologies can boost the operational efficiency of the existing power sector by accelerating the advancement in Internet of Things (IoT) structures. Consequently, this would contribute to increased innovation in Peer-to-Peer power business players and guaranteed decentralized generation systems. Additionally, blockchain technology brings in the advantages of automatic enhancements in existing practices of power sector players and power utility firms through mending their internal procedures, customer response, and cost (Bouttes, 2011).

The improvement of distributed energy resources, information, and communication technologies (ICT) has spurred notable transformational changes, primarily through the spring-up of decentralization and digitalization of the power systems (Mylrea & Gourisetti, 2017). This has been propagated by the attention, examination, and acceptance of novel paradigms and distributed automation in power systems management. Due to these facts, blockchain technologies could present a favorable framework to guide and oversee the consistently growing distributed and complex power systems and microgrids. The main challenge, therefore, remains the ability to integrate all the players in the power sector, which starts from independent power producers (IPP), distributed generation plants, transmission services, and the consumer's concerns. According to Mylrea & Gourisetti (2017), blockchain technologies could generate innovative business platforms where power sector players and consumers can transact mutually even within their elastic demand or energy surplus on a peer-to-peer platform. Through blockchain technology, effective consumer cooperation is achievable due to the possibility of stable, transparent, and secured intelligent contracts. The provision of such automated business platforms effectively conveys price changes and advice on power costs to clients through synchronously offering incentives for demand feedback and agile control of their energy demands (Mengelkamp & Gartner, 2018).

Additionally, blockchain technology can promote local power and customer-oriented microgrids that targets reinforcing local energy generation and utilization. This approach gives the considerable benefit of reduction in transmission losses and delayed costly network enhancement. Contrarily, power can be transmitted via the physical electric grid, where the demand and supply should be precisely managed and restrained to adhere to the power system's actual design constraints and stability. According to Eurelectric (2017), blockchain technology has been widely adopted by the transmission firms' power sectors compared to its employment in the finance industry. This has been enhanced by the ability of blockchains to securely document ownership and the source of the power used or delivered. Subsequently, blockchain technology can be employed for smart costing platforms and data storage in smart grids and cybersecurity. The power industry players' network resilience and supply security could be greatly boosted by blockchains through the acceleration of IoT applications, thereby generating more efficient elastic markets. According to Grewal & Marshall (2017), blockchain technology enables the power sector market operations to become more efficient and effective, thereby improving competition and expediting consumer flexibility through the provision of the ability to swap power suppliers. Therefore, maximum leverage on blockchain technology could enhance competition and help address power affordability challenges.

Based on the advantages exposed, blockchain technology have the potential to improve yield and better solutions across Kenya's power sector: this could be through cost reduction by optimization of power systems, improvement of power security systems in terms of cybersecurity, but also not forgetting to mention nurturing technology that could enhance the supply security, and lastly promotion of sustainable practices through facilitation of the green energy.

1.1.4 Power Sector in Kenya

Richter (2019) reported that the installed power capacity in Kenya was 2732MW, a momentous growth from 1800MW in 2014. However, given a population of 48 million, a considerable power shortage still exists. This has forced the Government of Kenya (GoK) to pursue efforts to enhance power supply at affordable cost by financing cheaper green energy sources such as geothermal, wind and solar. GoK aims to attain 5000MW by 2022, with the bulk energy source coming from geothermal, coal, wind and solar. Independent Power Producers manage approximately 30% of Kenya's installed power capacity (IPP) distributed across 15 power plants: three mini-hydro plants, one geothermal plant, 1 Biomass plant and ten fuel oil plants. The balance of 70% capacity comes from KENGEN, which is a 70% government-owned parastatal (Masyuko, 2020).

The Kenyan power sector currently boasts of some genuine success stories, a phenomenon that has been expedited by the strong initiatives and support from the top government divisions, harmonized contribution of the private sector in the generation, notable growth in connections, and a robust enabling environment for innovative green energy solutions. Currently, Kenya's policy and regulatory framework are reasonably advanced, evidenced by the significant growth in tariffs. According to USAID (2016), the current structure of Kenya's power sector starts from the Ministry of Energy and Petroleum (MoEP), which is mandated to formulate and articulate energy policies that create an enabling environment that natures operational efficiency and growth of the power sector. The Energy and Petroleum Regulatory Authority (EPRA), established in 2006, regulates and monitors the electricity sector. The National Land Commission (NLC) supports land acquisition in terms of the public and trust land in addition to the management of the wayleave process for electricity transmission lines. The Power generation industry players include the 70% government-owned parastatal Kenya Electricity Generating Company (KENGEN) with ~70% of current capacity, the Geothermal Development Company (GDC) that was founded in 2006 with the mandate to develop geothermal wells through surface exploration and steam drilling, Independent Power Producers (IPPs) that contributes ~30% of current power capacity. These, in total, sum up to approximately 2295MW of installed power generation capacity that is distributed across 42 power plants in Kenya. Over the past, the 50.1% GoK-owned KPLC (KP) enjoyed the monopoly of power distribution not until the private distribution companies were allowed under the current Energy Bill. The Kenya Electricity Transmission Company (KETRACO), founded in 2008, is mandated to construct new transmission lines and has currently done ~4149 km of infrastructure. The other important industry player is the Rural Electrification Authority (REA), founded in 2007 with the sole responsibility of expanding rural electrification by connecting public utilities and remote customers. However, all the connections done by REA are finally handed over to KPLC Company. The Kenya customer base currently stands at 3.6 million connections, which is at ~46%.

According to Kiplagat & Wang (2015), the Kenyan power sector is fronted with many challenges that are not limited to inefficiency generation systems, limitation of energy experts, outdated maintenance procedures for existing power plants, high losses along transmission lines, in addition to inaccurate metering and invoicing systems that induces delayed power supply. The power generation rate in Kenya has been approximated to a total operating expense (TOE) of 0.13 million USD, which is far below the targeted demand based on the country's economic growth. Electrical power contributes to approximately 10% of the total countrywide energy demand. Low access of about 4% in the remote areas and 70% nationally contributes to low national per capita energy consumption, estimated at 121 kWh per annum. A study by Power Africa (USAID, 2016) on the diagnostic of the Kenyan power sector to understand its contribution in converting the country from Good to Great (G2G) crosswise from power generation, transmission, and distribution. President Barack Obama launched Power Africa in 2013 with ambitious objectives of enhancing installed electricity capacity by 30,000 MW through developing 60 million new electricity connections. The partnership leveraged three fundamental components: An in-depth understanding of the Kenyan power sector, private sector-driven contracts, and maturity in collaborating with sitting governments to enhance guidelines and sector administration. These essential elements could be achieved by delivering at least 2700 MW new generation plants by 2020 through advanced financing and business models, development, and execution of a network strategy that assimilates both on-grid and off-grid platforms to realize affordable universal power access by 2020. Additionally, there is a need to resolve the wayleave challenges and enhance the power transmission network in Kenya, which is achievable by pursuing innovative solutions that quickly close on the 14-18 billion USD financing demanded by the Kenyan power sector to meet its targets. This study analyses how to achieve operational efficiency among the listed power industry players, leveraging blockchain technology to provide intelligent contracts in the power purchase agreements (PPAs) between power generation, transmission, and power distribution through proper tariff management, thereby nurturing transparency among all the power sector stakeholders. Blockchains attempt to address significant challenges in the power sector. For instance, enabling automated execution of smart contracts in electric mobility (e-mobility) through decentralized power trade that nurtures custom-made solutions to prosumers. Additionally, blockchains could also be applied in distributed ledger records in the billing and metering of power consumption which could be in varying aspects such as electricity, heat energy or electric mobility (PWC, 2016).

1.1.5 Operational Efficiency in Power Sector

Based on the European utility week article by Intel (2016), today's power sector is exposed to unprecedented demand, starting from the desire to integrate the distributed power resources to the ever-increasing maintenance cost caused by the aging power infrastructure. Power companies and regulators are now incurring more maintenance and construction costs caused by rising quantities of intermittent distributed power resources such as micro-grids, varying solar irradiance and battery systems connected to the distributed power grid. Consequently, increased dependency on varying power generation from renewable power sources such as solar has increased the outage risks compared to the old methods of power generation using fixed rotating electric generators.

Leveraging blockchain technology, Intel attempts to address these challenges face-to-face by providing power system solutions that enhance interoperability, reliability, and system automation by applying a scalable hardware and software framework (Intel, 2016). Blockchain-based infrastructure enables the power sector companies to develop new revenue sources through add-ons such as smart-home systems. Unfortunately, such a dramatic transformation in power generation and consumption may cause some shocks on the existing distribution grid, especially due to the risk of over and under-supply. Blockchain technology could quickly address these challenges, which nurtures more visibility and control by providing fundamental building blocks to actualize a secure and active grid management system (Rose & Alan, 2021).

Blockchain adoption by the power sector could optimize the line voltage, thereby reducing power losses and line deterioration while maintaining the desired power output level. This is achievable by accurately identifying sag sources reported from line sensors connected to the power lines, enabling the utilities to maintain preventative action and reduce power outages. Consequently, these optimize the power transmission across the feeder lines making load balancing, quick output restoration and safer protection systems achievable. Through blockchain, identification of losses by comparison of time-synchronized power measurements between the feeder points and downstream meter readings lowers the outage investigation time by correctly identifying the fault points at protection points. These operational efficiency metrics depend on data provided by smart devices that collect, digitize, and report instantaneous power qualities through smart utility networks (Intel, 2016).

1.2 Research Problem

Traditional approaches to evaluate operational efficiency provided only a retrospective outlook of a company's health. For instance, the traditional efficiency indicators cannot objectively tell why the overall results were as achieved or specifically highlight the company's divisions that need to improve to fulfil the pre-set company's strategic objectives. Consequently, this calls for a need to complement classical efficiency indices in a more aggressive sequence on both effectiveness and efficiency, resonating with explicit conditions of a current competition (Rosova & Michal, 2012). Presently, operational efficiency gained from technological advancements such as blockchain disrupting the power industry from generating, transmitting, and distributing electrical energy remains the main question. This is based on the reality of high system losses incurred in the technical and commercial processes originating from growing transmission and distribution networks (Alushula, 2021).

Kuria (2013) covered an assessment of operational challenges facing the performance of thermal power plants in Kenya. His recommendations disclosed challenges affecting thermal power plants in general. However, his study needed to be broadened to cover the ways to enhance operational efficiency in the whole power sector by considering all the major players in the energy industry.

This study did not provide solutions to the operational efficiency challenges observed by the thermal power plants. Low efficiency in operation from generation, transmission, and distribution of electrical energy has been highlighted as one reason contributing to the high cost of power in Kenya. Kagiri & Wainaina (2009) exposed the failures of inefficient distribution systems identified by constrained redundancy and archaic production systems. In his study, Tumino (2021) revealed the challenges of centralized and distributed generation plants, specifically on-grid stations. Additionally, Kiplagat, Wang & Li (2011) studied the resource potential and status of exploitation, specifically in Kenya's renewable energy sector. Gachunga (2018) investigated capacity management strategies and operational efficiency in Kenya's energy sector. None of these works objectively spotlight the operational efficiency of the whole power sector from generation, transmission, and distribution.

Cryptocurrency applications in the power sector for commercial transactions have provoked the establishment of new joint ventures and partnerships. For instance, in South Africa, Bankymoon is a startup that utilizes smart prepaid meters to connect electricity to residential homes based on mini-smart contracts. That is, once the customers have made payments to the power utility, the system uses bitcoin as cryptocurrency to enhance the customer's payment discipline, thereby benefiting the supplier. Additionally, residential consumers also enjoy the advantages of protection from high inflation rates, especially for prepay payment contracts. For instance, donors supporting needy public schools can directly send crypto funds to the school's smart meters, enabling poor schools to access uninterrupted power supply at an affordable cost (Stan, 2016).

Iceland's cryptocurrency miners have pushed the power demand limit due to increased interest in bitcoin mining. Richter (2018) reported that accrued interest in cryptocurrency mining could push up Iceland's energy consumption by 100 MW. Runtimes mainly caused the demand for operating powerful macro-computers. The skyrocketing bitcoin prices have enormously increased interest in cryptocurrency. Conveniently, 30% of Iceland's energy comes from geothermal power, which means that these geothermal power resources of Iceland are sustaining bitcoin mining.

In Germany, BlockCharge is an application of Ethereum blockchains to enable the charging of electric vehicles and bikes. Stocker (2016) noted that the BlockCharge utility provides a seamless and cost-effective charging source for electric vehicles in Germany. The technology uniquely applies physical smart plugs that are programmable and are only once purchased, provided a micro-transaction levy for charging cost is billed. Customers install the BlockCharge application on their smart gadgets through which they can initiate the charging process. This application applies blockchain to manage and record all the charging transactions and billing systems without intermediaries. Additionally, BlockCharge is intelligent enough to negotiate the best prices and automatically complete all transactions between users and the utility.

For these renounced studies, little effort was put into improving operational efficiency in Kenya's power sector. This study extrapolates earlier studies by exploring how blockchain technology can respond to these operational inefficiencies. Specifically, we ask how blockchain technology can respond to the operational inefficiency in the Kenyan power sector?

1.3 Research Objectives

The broad objective is to establish how blockchain technology can enhance operational efficiency in the Kenya’s power sector.

Specific objectives are:

1. To map out the potential applications of blockchain technology in Kenya’s power sector.
2. To investigate the impact of blockchain technology on operational efficiency of the power sector in Kenya.
3. To analyze the constraints in adoption of blockchains in Kenya’s power sector.

1.4 Value of the Study

This study will conventionally contribute to the following aspects:

To the power sector shareholders- The study will influence investment decisions and collective efforts of public and private sector players in the ambitious roadmap of doing at least 60 million connections in sub-Saharan Africa by 2030.

To the power sector management- It will guide the management team of main industry players in the power generation, transmission, and distribution to address the known industry challenges by seeking solutions to the weaknesses and putting more effort into the strengths.

To academia and research- The study will support enhanced research in the application of blockchain technology in the power sector from generation, transmission, and distribution of electricity.

To the government of Kenya- It will encourage the government of the day to provide strong leadership at the top levels through the enactment of laws that provide a robust enabling ambience for innovation in both on-grid and off-grid power solutions.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

This chapter reviews the theory underpinning the research project, blockchain technologies and how they enhance operational efficiency in the power sector. Related studies are reviewed therein, and research gaps addressed by the current research are identified.

2.2 Theoretical Review

This section highlights some of the key theories that underpin this study, specifically the knowledge-based, system and stakeholder theories.

2.2.1 Knowledge-Based Theory

The Knowledge-based theory strategically considers knowledge as the essential resource of the organization. However, due to its socially complex nature, this significant resource cannot be easily imitated from one firm to another. For any organization to develop a sustained competitive advantage and a world-class corporate performance, there is a need to establish a knowledge basis and heterogeneous capabilities to withstand the dynamic nature of energy markets (Nickerson & Zenger, 2004).

According to Curado (2006), there exists a need to economically balance between material-based production and knowledge-based production, especially regarding the revaluation of the firm's employees as a factor of production. Progressively, knowledgeable employees are always at the core of the organization's functions. For instance, the design team involved with the idea conceptualization and technology design and the financing and management team must possess in-depth knowledge of the firm's core function. Other players are at the firm's periphery. Subsequently, their obligations differ momentarily, leading to unique, differentiated labour.

Consequently, many organizations understand that to achieve efficacy in their current economy, they must develop into a knowledge-based organization. However, the organization's top management must correctly understand the meaning and process of this transformation to avoid common mistakes. For instance, the assumption is that the higher the knowledge capacity of their products and services, the closer they are to becoming a knowledge-based organization. Unfortunately, products and services represent just the tip of the iceberg, with the bulk contributor to the firm's output being the intangible assets such as the knowledge of the firm's core function, that is, the process and objective of developing the final product and services (Zack, 2003).

Knowledge-based competencies are treated as the top-ranked strategically important input factors used to develop and sustain competitive advantage. Superior talent is the principal architect of sustained competitive advantage in most high-performance organizations (Nickerson & Zenger, 2004). The ability to develop new concepts faster than the competitors could be the only sustainable competitive advantage enjoyed. Consequently, casual ambiguity evidenced by the creation of imitability barriers develops, thereby making it very hard for competitors to re-create the unique historical advancements that the innovative organization is famous for (Sheremata, 2008). Consequently, for this study, knowledge-based power sector firms will benefit from improved operational agility through quicker and better decision-making procedures brought about by increased efficacy provided by ontological tools and rules that directly address operational challenges in the power sector.

2.2.2 System Theory

Mele, Pels & Polese (2010) note that a system is a complex or organized whole, an assembly of parts that develops into a complex unitary whole. The system theory provides a framework for envisioning the internal and external environmental factors as a unified whole. The acceptable reality is that the system within which most business entities operate is very dynamic and complex. However, management through systems concepts advances a school of thought that helps address some challenges by fully exposing the complexity, enabling management to operate within the perceived environment. Additionally, every business system, whether open, closed, or isolated, has inputs and outputs, making it part of a more extensive system, possibly industry-wide, that is, made up of multiple companies critically interacting with the external environment to remain alive. Furthermore, the conception of learning is vital to smart systems and blockchain applications intended for offering interactive management of assets and targets with the ability of self-reconfiguration. Subsequently, this guarantees enduring performance that satisfies all the industry players in time. The innovative attribute of a system controls all stages; that is, the front-stage input must detect critical features for self-improvement and reconfiguration. However, the backstage ought to depend on control functions capable of supporting operational variations and time efficacy. Such intelligent systems react through technology and develop the ability to seek the intelligent and intelligent optimal use of scarce resources (Mele, Pels & Polese, 2010).

According to (Tien & Berg, 2003), the smart systems developed can search for reactive, dynamic, and innovative computer-based solutions to provide sustainable competitive advantage and high system performance. Consequently, the smart system provides a centralized concept of organism adaption that entails applying self-advancing intelligence with the capability to observe the environment, develop a contextual pattern and continuously improve. Blockchain technology, a classification of interlinked ledger accounts connected by dependent blocks, heavily relates to the system theory given the interconnection and feedback loop between the input and output elements.

Likewise, blockchain is a modern way of operation, an innovation strategy that enhances competitive advantage to organizations (Mohamud, 2020).

2.2.3 Stakeholder Theory

The narrative of the stakeholder theory attempts to understand and address three correlated business challenges- the problem of exploring how value creation and trading are achieved, the challenge of interlinking ethics and capitalism, and the challenge of ensuring managers embrace management systems that address the first two challenges concurrently (Freeman, Parmar & Harrison, 2010).

Conspicuously, the 21st century has been bedeviled with many corporate scandals such as Enron, Tyco and WorldCom, which depicted organizations and executive heads to mind very little on ethics in the pursuit to gain profits. Clement (2005) reports that the actions by the management directly affect a broad scope of industry players globally, that is, by the confluence of circumstances, specifically in the housing markets and secondary markets, thereby enhancing the disengagement of Main Street from Wall Street.

Furthermore, management's pursuit of corporate objectives and targets could easily be affected by unprecedented demands from industry players and individuals. Such challenges, propelled by the need for transformation and interlinkages, reveal the demand for management and academicians to re-strategize the traditional methods of viewing the firm's responsibilities (Freeman, Parmar & Harrison, 2010).

Additionally, over the last 20 years, notable efforts in testing concepts and models by academicians and industry practitioners have propelled an understanding of the dynamics of business challenges in today's markets. Inclusive to these, stakeholders' perspectives emerged as the latest narrative to be explored to address three main business challenges- the need to endure value creation and trading, the challenge of linking ethics to capitalism, and the task on managers to address the two problems. In summary, the three problems should be addressed not only theoretically in management but across multiple disciplines that would re-define capitalism (Clement, 2005).

2.3 Potential Blockchain Application in Power sector

2.3.1 Peer-to-Peer Power Trading and Operational Efficiency

Blockchain, the technology that supports Bitcoin, was initially released in the whitepaper "Bitcoin: A Peer-to-Peer Electronic Cash System" by Satoshi Nakamoto in 2009 (Satoshi, 2009). This described a peer-to-peer, open-source crypto-currency system that answers digital trust evidenced by transparent, time-stamped, and decentralized transactions. Over the last decade, technology has developed into one of the many innovative ideas to impact most industries, such as finance and the power sector.

The case study of the Brooklyn microgrid is clear evidence of a blockchain-based peer-to-peer energy business platform known as the Transactive Grid. This is a partnership between four business entities, that is, L03 Energy, Siemens, Centrica, and Consensys. The energy prosumers can sell their extra power directly to their customers using Ethereum-based smart contracts. The energy surplus through net metering is measured using special smart meters that generate equivalent energy tokens, which are tradable in the local marketplace. Blockchain technology enables the transfer of the energy in the tokens from the prosumer's smart meter wallet to the end customer's device. As the customer continues to use the electricity in the house, the tickets are automatically decremented via the customer's smart metering device. (Mengelkamp, Garttner, Rock, Kessler, Orsini & Weinhardt, 2018).

Assuredly, the microgrid users connect with the platform by clearly defining their price preferences by consenting to transact for the electricity. Through the platform, the ledger records the contract terms, industry players, and power capacity produced and consumed in chronological order. Additionally, all payments are undoubtedly initiated by self-executed smart contracts. Every industry player gains access to all the historical transactions and events from the ledger, which are verifiable without any restrictions (Robu & Merlinda, 2019). This enhances operational efficiency and competitive advantage for firms applying blockchain technology compared to those that do not.

2.3.2 Decentralized Power Trading and Operational Efficiency

Blockchain technology enables the adoption of peer-to-peer networking, eliminating the need for a mandatory control center. Additionally, every node in the network possesses equivalent and independent status on the whole system since its inception. Therefore, the generated data blocks in the entire history are constants recorded and stored as transaction data, enhancing the database's robustness and operational efficiency (Jiani & Nguyen, 2018). For instance, if one of the nodes in the system has an error, thousands of other nodes are used as reference points to correct the identified error. Consequently, no node within the system can change the information stored within it. Therefore, the historical data of all transactions in every block making up the system is irreversible (Conway, 2021).

The decentralized energy business has currently employed most blockchain technology. Developers in this industry have created several solutions that support wholesale electricity trading and peer-to-peer energy trading between prosumers and consumers. In addition, this has created platforms that enable end-consumers to access wholesale power markets. Ordinarily, blockchains minimize transaction costs in wholesale energy trading and provide transparent information accessible by multiple stakeholders and bodies certifying regulatory compliance. Consequently, to adjust the functionality of the system or any data stored, bulk decentralized networks of computer programs would need to have consensus. This ensures that the variations made are always in the best interest of the majority of stakeholders (Eurelectric,2017).

However, the limitation of having a fully decentralized system is linked to the scalability and speed of transactions supported by a blockchain system. Additionally, a notable concern arises when commercially sensitive data gets open access to all the industry players. For instance, the parties mandated to provide the end consumers with access to power markets can generate new flexibility provisions for the grid. Subsequently, such initiatives enhance consumer awareness and informed decision-making concerning power supply leading to efficient operation and competitive advantage (Robu & Merlinda, 2019).

2.3.3 Imbalance settlement and Operational Efficiency

According to Elexon (2019), electricity cannot be stored in bulk but is only generated, transmitted, and distributed instantaneously in real-time. Consequently, the power industry players with demand, such as the power distributors, contract to purchase a pre-defined volume of electricity from the generators. Additionally, once the power is delivered onto the transmission line in real-time by generators, it is indiscriminately used on-demand basis; that is, the power generation targets only where the system shows demand rather than directly to the customers that initiated the first contract.

However, the delivery of electricity can be affected by system constraints. For instance, applying the traffic analogy, traffic congestion may demand generation to be halted in one power station and increased elsewhere to solve the jam and ensure continuous delivery of electrical energy. Therefore, the power system operator ensures that a sustained real-time system balance exists and that the supply always meets demand. Unfortunately, PwC's (2016) study exposed that the imbalance between supply and demand may take up to 28 months to finalize. The delays experienced are caused by the tedious reconciliation procedures in data volume materialization and confirmations. Blockchain technology can help undercut such costs and time delays by minimizing the numerous back-office processes. The power generated and distributed can be traced and recorded in a transparent and open ledger, accelerating the transactions between the different parties involved in the supply chain.

According to PwC (2016), through the employment of blockchains, shareholders can reduce credit risks and collateral demand. Additionally, a transparent and efficient market close to real-time confirmations is achievable. For instance, the blockchain-dependent platform can support businesses between the varying industry players, promote auditing and system integrity, minimize malicious risks by secured data storage advantage and enhance inter-operability across all the power industry players. Furthermore, regarding imbalance settlement, blockchain-dependent smart contracts allow accurate auditing. For instance, the energy regulator can identify the specific generator and customer that created an imbalance in the whole supply chain process, thereby providing real-time billing. However, the challenge of latency and low transactions per second remains the prioritized goal for the power regulator. In addition, the smart-grid vision of ex-post balancing transactions that incentivize real-time customer behavior change persists. For instance, that smart system enables customers to receive real-time information to reduce their power consumption in excess renewable power generation scenarios, thereby enhancing operational efficiency and competitive advantage over rivals (Robu & Merlinda, 2019).

2.3.4 Digitalization by IoT platforms and Operational Efficiency

Auspiciously, blockchain application in the emerging fields of the internet of things (IoT) and embedded system electronics has facilitated peer-to-peer transactions, thereby enabling machine-to-machine (M2M) communication through time-stamped data transmissions between smart devices and the server (Trivodaliev & Stojkoska, 2017). By 2020, Burger & et al. (2016) projected that an estimate of around 20.8 billion smart devices globally could be added to the internet. For instance, in the power utility industry, smart metering and computerized energy systems are progressively being embraced at a first global rate of between 20 million to 220 million per day (Jaradat Jarrah & et al., 2015).

Subsequently, the power sector's supply chain value and operational efficiency can be transformed with this trend coupled with the advantages of automation and big data analytics. Ordinarily, meaningful data augments the efficacy of power systems and asset diagnostics, thereby promoting cost reduction (Merlinda et al., 2019). Digitalization provides a platform to improve system efficiency in the billing and supply chain processes, thereby supporting innovative and unique business ideas. Similarly, data utilization facilitates demand identification and response optimization by developing Virtual Power Plants (VPPs). This enhances active consumer involvement and integration of renewable energy into the primary value chain (Saglroglu, Terzi, Canbay & Colak, 2016).

Additionally, digitization of power systems minimizes management costs, especially for small-scale power generators, through smart integration of embedded system engineering, data analytics, and cloud connectivity. The vision of the smart grid is that the distributed machine-to-machine (M2M) interconnected smart devices would finally coordinate and respond to market prices and green energy utilization by power consumption adjustments. However, applying centralized systems in large-scale devices becomes inefficient, especially when a large data volume at high frequency is involved. Therefore, blockchain technology can track the electricity produced by each smart device, thereby enabling trading between varying machines in the pool of connected assets. Based on customer preferences and willingness to transact, the optimal bidding approaches to trade are developed through the platform, thereby enhancing operational efficiency and competitive advantage for the industry players adopting the blockchains (Merlinda et al., 2019).

2.4 Empirical studies and Knowledge Gaps

Linus Foundation & IBM (2017) explored the Hyperledger architecture as an open-source collective exercise that enhanced cross-industry blockchain technologies. The study served as a cross-project platform for technologists and architects from various Hyperledger sectors to analyze and share ideas of possible architectural tradeoffs and options. The main objective was to design a modular architectural structure that supports enterprise-based distributed ledgers. Additionally, the study identified the critical variables by integrating enterprise blockchain stacks into segmented layers and modules. This finally proposed the standardization of linkages between various components, ensuring operational efficiency between the ledgers (Linus & IBM, 2017).

In Spain, Alastria (2017), a study on "Alastria national blockchain ecosystem," entailed a national blockchain initiative for divergent sectors such as megabanks, top energy companies, government, and research institutions across Spain. According to InnoCells (2019), Alastria was the world's first standardized national network providing a common synergetic platform established on blockchain technology. The objective was to develop a public digital distributed ledger system platform that complied with European Union and Spanish regulations and legal considerations.

In Holland, BlockLab (2020) studied the feasibility of blockchain technologies in the logistics and energy sectors. The initiative was funded by the City of Rotterdam and the Port of Rotterdam, attracting the Netherlands government and academia. BlockLab supports pilot projects by collaborating with developers, engineers, and end-consumers to create platforms that enhance world-class operational efficiency in the power sector. Additionally, the European Union initiated a blockchain technology observatory and platform that highlights significant developments of blockchains and promotes and reinforces the engagement of stakeholders and the government (Vandystadt, 2018).

Mohamud (2020) researched blockchain as an innovation strategy for competitive advantage by the Kenya Red Cross society. He applied a descriptive case study approach through which primary data was collected using an interview guide. The study established that despite blockchain nurturing transparency and trust to donors, the technology demands continuous, sustainable funding and resources to be implemented effectively. A survey conducted by Kaburu (2011) used a case study research design and content analysis to research the importance of blockchains at the Kenya medical supplies agencies (KEMSA). The study found that the technology-enhanced security by limiting corruption through efficient record-keeping and data tracking within the medical supplies' companies in Kenya.

Ouma (2015) researched the advantages of blockchains in Kenya's parastatals. The study established that it is possible to achieve a highly secured and effective organization through blockchain technology by leveraging innovation to realize a competitive edge between common cadre organizations. The study concluded that the employment of blockchain technology nurtures transparency in reporting across state agency departments, enabling institutions to enjoy operational efficiency and quality services. A study on the effects of blockchain in Kisumu County established that the benefits accrued outweighed the challenges. Odongo (2014), therefore, concluded by exposing the importance of blockchains in tracing ledgers and data from multiple departments. Additionally, all generated transaction reports are hard to amend; hence secure and transparent.

Wahome (2020) conducted a study on the application of blockchains in the informal distributed manufacturing industry in Kenya. This study explored how blockchain technology provided traceability, visibility, and transparency in Kenya's informal distributed manufacturing sector. The researcher used interviews and observations as data collection methods, while content analysis and qualitative data analysis methods were applied to apprehend emerging and future manufacturing sector trends. The study concluded by recommending future research to zero in on unit-based tagging technologies applied concurrently with blockchains to achieve advanced traceability levels, specifically when dealing with divergent producers dealing with common products.

Likewise, Chepken (2018) researched the application of blockchain technology in asset management, specifically in Kenya's county assets. The study experimented by targeting county government assets in reference to blockchains to validate and verify the procedures and stipulations laid down to manage county government transactions. The outcome indicated that the designed blockchain platform met the major requirements of verification, validation, and consensus in managing county resources.

2.5 Global power sector survey

The power sector companies globally are forced to adjust their operational management structure to accommodate the energy market's transformations continuously. For instance, the need for price reductions that consequently lead to limited profit margins upgrade of supply quality that has been fueled by market demand for new products and services. At the same time, they still remain sensitive to environmental protection (Deloitte, 2012).

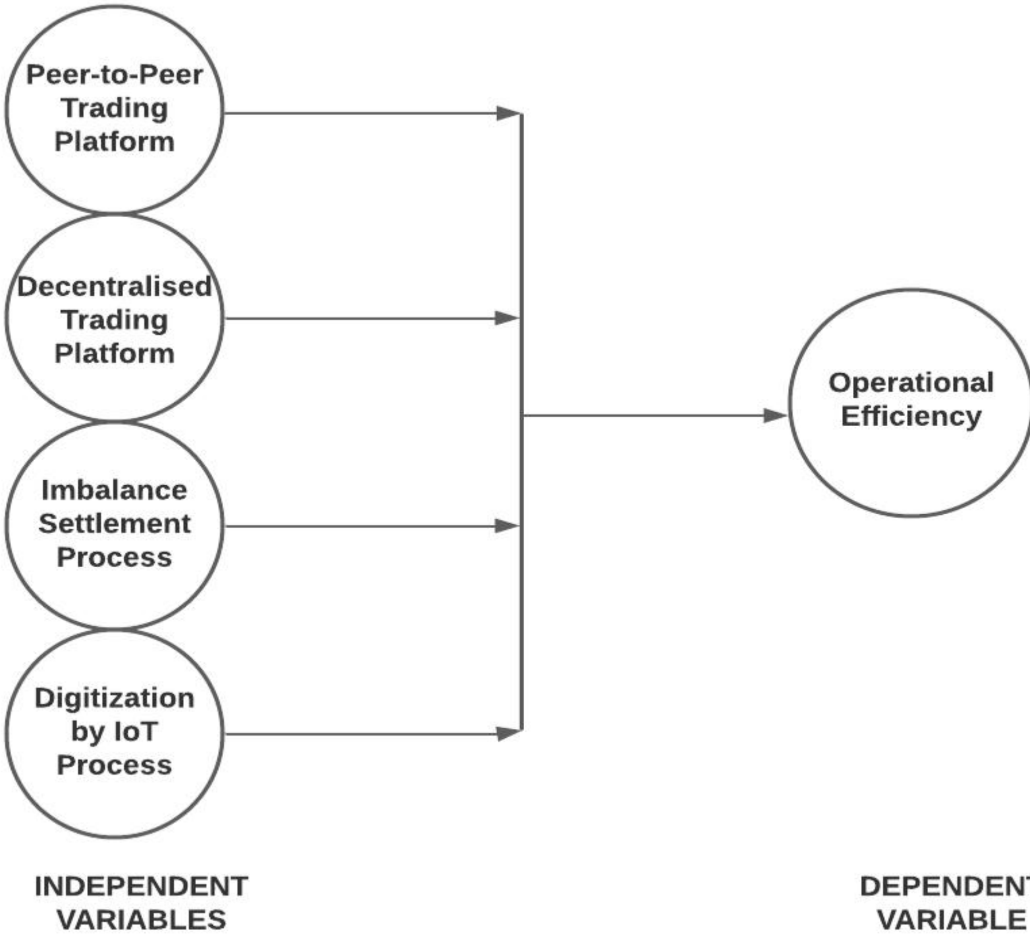
World Energy Outlook (2014) reported that nuclear power sources possess lower marginal costs than other conventional power alternatives despite nuclear energy production being carbon-free with a stable supply. Countries with nuclear power across Europe, such as the United Kingdom (UK), are faced with increased operating costs brought about by the new security standards. Most power companies in the UK strive to achieve their carbon dioxide (CO2) reduction targets that beset the renewables surge while still being sensitive to maintaining the energy prices at affordable ranges. Unfortunately, after the Fukushima incident, the demand for nuclear power decreased globally, and some regions considered phasing out nuclear energy sources. Consequently, this has created a noticeable energy demand gap that must be filled to avoid energy dependence risks. Contrarily, India, like other Asian regions, still advocates for the benefits of nuclear energy and targets to install another 34 GW of nuclear power stations. Although nuclear power is declining across Europe, the UK is carefully designing a blended power supply strategy composed of huge subsidized modern nuclear plants.

According to Deloitte (2012), North America globally tops the shale gas exploration and utilization at 40% of total United States gas production as of 2012. Shale gas has remained a competitive power source and poses noticeable threats to other energy generation alternatives. Currently, countries such as Mexico, Denmark, Argentina, and China have attracted major oil and gas companies to drill new wells. However, most countries are preserving their local reserves and are waiting to observe how the potential of gas trades outside the United States would contribute to global power pricing. An indexing breach on Liquefied Natural Gas (LNG) to crude oil could be catalyzed by enhanced utilization of the shale deposits coupled with the fact that the US gas prices are lowest globally. Subsequently, despite the massive drop in oil prices from 2014, LNG prices connected to the gas nerve centers are predicted to be less than those for oil-indexed LNG. These noticeable facts will culminate in the LNG markets growing to be more global.

2.6 Conceptual Framework

Conceptual framework refers to the synthetization of correlative variables and components that assist in problem-solving a real-world challenge (Imenda, 2014). It is a magnifier applied to examine a logical problem's derivable decision. From the research topic, the following conceptual framework was adopted.

2.6.1.1 Conceptual Framework on Operational Efficiency



CHAPTER 3 : RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents research design, population, sampling and techniques of data collection and data analysis.

3.2 Research Design

The study adopted a descriptive research design. A descriptive research case study enables the determination of the recurrence of a phenomenon or, similarly, the correlation between variables in each study (Bell & Bryman, 2011). Descriptive research design is an accurate approach for investigating explicit subjects and can be a vital lead to qualitative analysis. In this study, descriptive research permitted a comprehensive study of blockchain technology and operational efficiency in Kenya's power sector. Additionally, background examination provided by descriptive research allowed it to incorporate objective data accurately without manipulation (Noor, 2008).

This cross-examination heavily relied on the background investigation approach, given the advantage of covering the objective data without manipulating the variables. According to John (2013), a case study scrutinizes policies, projects, times and activities, or variables in blockchain technology that can be accurately and strategically addressed. The unit of examination considered categorized phenomena that provided collaborated analytical structure, an associate body at lacuna that the study is carried out, and that the study highlighted explicitly.

3.3 Population and sampling

The study's target population included all the main industry players in Kenya's power sector from generation by (KENGEN) and the independent power producers (IPPs). KENGEN is the largest single electricity producer in Kenya that is, generating 78% of electricity locally consumed and is largely public and partially privately owned; transmission by (KETRACO) which manages the national transmission grid, distribution, and retail by (KPLC), and finally, regulation, monitoring of upstream energy and petroleum data by (EPRA). The independent power producer (IPP) selected is the OrPower 4 (Geothermal), which is the largest generator IPP in Kenya. The largest fintech solar company in Kenya (M-kopa) was selected for the study.

3.3.1.1 Main Power Industry Players in Kenya

Power Sector	**Company**	**Main Function**
Generator	KENGEN	Charged with management of all public power generation
Transmitter	KETRACO	Mandated to develop new transmission infrastructure
Distributor	KPLC	Electricity capacity to demand planning and billing
Regulator	EPRA	Enforcement and review of electricity tariffs, safety and environmental regulations.
IPP	OrPower 4 Inc	The largest IPP that generates power from geothermal reserves and sell bulk electricity to KPLC
Fintech	M-kopa Kenya	Connected assets financing platform offering clean energy solutions

3.4 Data Collection

The study generated essential data from practicing power industry players in the following disciplines: heads of departments, business unit managers, engineers, ICT, and logistics officers. This is owing to their conversance with blockchain and its advantages, given their training background and years of work experience in the power sector.

The specific organizations targeted included KENGEN-Olkaria one to four power stations; the fintech energy firm includes M-kopa Kenya Limited, the transmission firm being KETRACO, while the regulator is the energy and petroleum regulatory authority of Kenya. The primary data was obtained through an interview guide that targeted understanding operational efficiencies and challenges across the supply chain processes of the power sectors, which blockchains could help address.

3.5 Data Analysis

The study presented objective information and therefore applied content analysis to map out the potential of blockchain technology in Kenya's power sector. Mugenda (2003) describes content analysis as a strategic tool to develop a summarized and scholarly impartial decision through collaborative sequences. To achieve more revelation on study gaps, the information obtained from the industry players was compared to the other to reveal the potential applications of blockchains across power industry players, thereby meeting the study's first objective.

Content analysis was applied to analyze the specific data obtained from the interview guide recording, thereby meeting the second objective, which was to investigate the impact of blockchain technology on operational efficiency through the development of subjective information. Using the theoretical approaches in the literature review, the data collected was compared to attain an objective conclusion on the constraints facing the adoption of blockchain technology in Kenya's power sector.

CHAPTER 4 : DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents an analysis, interpretation and discussion of the data collected from the respondents established from the study objectives and research problem. The objectives of the study were:

1. To map out the potential applications of blockchain technology in Kenya's power sector.
2. To investigate the impact of blockchain on operational efficiency of the power sector in Kenya.
3. To analyze the constraints in adoption of blockchains in Kenya's power sector.

4.2 Study Respondents

As alluded to earlier in the third chapter, the study employed a qualitative approach to collect primary data from the defined population. Twelve respondents from six firms participated in the interviews. These entailed two [2] Heads of Department, two [2] Business Unit Managers, three [3] Engineers, three [3] ICT officers and two [2] General management officers. The firms included KENGEN (generator), KETRACO (transmitter), KPLC (distributor), EPRA (regulator), and Orpower 4Inc. (IPP), and M-kopa (Fintech). Due to the COVID-19 pandemic, most respondents worked from home, so face-to-face interviews were impossible. The respondents were therefore interviewed via telephone calls and video conferences. Triangulation of the objective questions distributed in the interview schedules checked and collected valuable views on how blockchain technology can enhance operational efficiency in Kenya's power sector. Additionally, triangulation enabled the researcher to check on biasedness through cross-validation of collected data.

4.3 Findings on institutional architecture of Kenya's power sector

The study desired to establish the institutional framework of the vital industry players in Kenya's power sector and how their operational efficiency can be enhanced by blockchain adoption. The respondents comprised mainly senior managers and consulting engineers with at least ten years of service that is distributed from operational, tactical, and strategic management. Respondents were asked to categorize the core functions of their organization in the power supply chain.

In summary, the study findings on the mandates and responsibilities of the key Kenyan power sector industry players established a correlation to the sustained public complaint from power consumers and prosumers about the ever-increasing cost of power distributed by KPLC. Operational inefficiencies and ineffectiveness of the Kenyan Government through MoE, existing power generators, and power transmission and distribution networks frustrate Kenya's ambition of transforming into a globally competitive, industrialized middle-income economy by 2030. The respondents mentioned that the high cost of power generated by IPPs is one of the main contributors to KPLC's alarming financial position. For instance, one of the respondents was concerned about the paradox that IPP supplies

approximately 25% of KPLC's energy which translates to 47% of the distributor's total power purchase expenditure. Interestingly, KENGEN supplies approximately 72% of KPLC's input, which only equates to 48% of KPLC's power purchase expenditures. The respondents added that only a balance of 2% purchased by KPLC comes from REREC and imports from Ethiopia and Uganda. From these observations, the study observed an apparent power mix misalignment between the interests of shareholders from IPPs and those of KPLC in reference to the cost of power.

The respondents agreed that through blockchain adoption, structured engagements between the Government power sectors from the MoE, EPRA, REREC, KENGEN, GDC, KETRACO, KPLC IPP and the Fintech would spur transparency for stakeholders without compromising privacy, reduce power costs in an environmentally sustainable manner. Blockchain, through its smart contracts and system interoperability, would ensure due diligence and adherence to agreed frameworks for all power contract implementations and monitoring.

4.3.1 Ministry of Energy (MoE)

The study ascertained that the MoE is mandated to develop and oversee the implementation of the energy sector policies. It was established that blockchain adoption by the ministry would spur efficient operation and growth of the power sector. For instance, one respondent commented that the transparency brought about by blockchain's digital ledger would expedite the ongoing formulation and development of the Integrated National Energy Plan (INEP). This would enhance the continuous improvement and publication of the national energy policy through stakeholder consultation as prescribed by Section 4 of the Energy Act 2019.

The study ascertained that based on the Energy Act 2019, MoE's involvement at the different levels of the supply chain, from procurement, regulation, generation, transmission, and distribution, is an outstretch and outside its defined mandate. The respondents suggested that effectiveness would be achieved if the power sector was unbundled, that is, by restructuring KPLC's state-owned monopoly into an open merchant system that allows power to be sold in a spot market. However, the ministry has not effectively achieved this function, evidenced by the dependency challenges that the other power sector players exhibited. Consequently, the respondents noted that the inefficient coordination has resulted in the duplication of functions typically addressed by specific power industry players. Blockchain adoption would address these challenges of overlapping duties, achieving the desired accountability and efficiency across the power sector in Kenya. For instance, blockchain combined with IoT devices would effectively replace services such as metering and billing. This would enable power consumers to trade and buy power directly from the grid rather than through a power retailer. Additionally, by connecting consumers directly to the national grid, Ethereum enables an open power transaction where consumers purchase power at a cost they wish. This results in a more stable and equitable power market with lower costs to the consumers.

4.3.2 Regulator-Energy & Petroleum Regulatory Authority (EPRA)

The study established that EPRA, an independent authority entrenched under the Energy Act 2019, was developed pursuant to sessional paper number four of 2004. The main objective was to regulate the whole power sector, including and not limited to electrical power, petroleum, and renewable energy. The respondents at EPRA highlighted the main functions of the authority that would employ blockchain technology, thereby achieving operational efficiency. For instance, smart contracts could be adopted in developing electrical power tariffs and structures by considering the financial structures, feasibility studies and proposals from energy consultants before approval of any proposals from independent power producers (IPPs). The respondents added that distributed ledgers provided by blockchains would improve energy data collection and maintenance. Consequently, this would simplify the approval of contracts and the development of relevant tariffs between the power generators and the off-taker (KPLC).

The study established that EPRA as the regulator, must be neutral and should not be involved in the procurement of power generation projects that are legally addressed by the Feed in Tariff (FiT) committee. The respondents appreciated that a neutral and objective regulator would win the trust of the off-taker and the project investor. For instance, EPRA is mandated to regulate consumer tariffs without involvement in KPLC’s tariff review processes. However, the study noted that investor protection was prevalent in the power consumer’s interest. The respondents agreed that blockchain distributed ledger technology would address this challenge, where business Ethereum processes and validates data from IoT devices at the national grid before reporting onto the blockchain’s databases. Secondly, KPLC can apply blockchain to generate a system for data transactions that is important for efficient power distribution. Lastly, the distributed ledger technology provides flexible models for transacting power covering diverse customer metering and billing requirements such as post-pay, pre-paid and net-metering options.

4.3.3 Rural Electrification and Renewable Energy Corporation (REREC)

The respondents described REREC as a public entity established under the Energy Act 2019 with the main objective of expediting the speed of rural electrification in Kenya. The financier of the corporation is the Rural Electrification Program Fund; the Parliament appropriates monies allocated from the existing consolidated energy fund. This promotes the development of renewable energy projects and initiatives in Kenya.

The study observed overlaps and duplication of functions between MoE, KPLC and REREC. This has resulted in several funding instruments for the Rural Electricity Program, such as the Government of Kenya (GoK), Constituency Development Funds, the Rural Electricity Scheme, and the Petroleum Development Levy. Consequently, this has created a challenge of accountability and efficient use of the availed funds.

The respondents added that all the infrastructure developed by REREC is finally handed over to KPLC for operations and maintenance. The challenge, however, is that the allocated funds are insufficient to compensate the off-taker. The GoK has not paid considerable funds to KPLC, consequently being owed significant funds by REREC. This intricate pattern causes challenges in ascertaining the correct financial position of each power sector, thereby negatively affecting the cost of power paid by the consumer. The respondents appreciated that blockchains could adequately address this dilemma.

Generally, a clear delineation lacks the functions of REREC and KPLC. For instance, the respondents noted that KPLC distribution systems have recently expanded to markets that ordinarily could be more remote in reference to REREC's scope. Consequently, this has significantly expanded the mandate of REREC to be a power generator and distributor even though it lacks the capacity to develop, operate and maintain such major projects. Therefore, to achieve accountability and transparency, there exists a need to streamline the functions of KENGEN or IPPs, REREC and KPLC before embarking on any future project.

4.3.4 Generator-Kenya Electricity Generating Company (KENGEN)

The respondents boosted KENGEN's recent expanded technical capacity and scope in the implementation of major geothermal projects both within the country and neighboring states. For instance, the respondents mentioned that in October 2019, KENGEN secured a Kshs 6 billion contract to drill at least twelve new geothermal wells in Ethiopia successfully. Additionally, in February 2021, the power generator secured another USD 6.4 million tenders to successfully drill three geothermal wells in Djibouti.

The respondents established that power generation projects managed by KENGEN that are of similar scope and technology and are within the same geographical location were cheaper and provided lower tariffs. Unfortunately, the respondents added that KENGEN and GDC exploration projects are not coordinated as they should be. Through blockchain adoption, the synergy in operations between KENGEN and GDC during the exploration and utilization of geothermal resources would immensely lower the cost of power in Kenya.

The respondents underscored the challenge that some of the projects implemented by KENGEN are beyond the Least Cost Power Development Plan (LCPDP) scope. This resulted in alterations of predefined generation capacity. The respondent appreciated that blockchain technology would quickly fix this problem, given its unique security of predefined specifications through cryptography.

4.3.5 Geothermal Development Company Limited (GDC)

The respondents mentioned that GDC's core function is the development of new geothermal steam fields and commercializing the gained steam for power production. The respondents added that their main customers are KENGEN and independent power producers such as Orpower 4Inc. The major concern raised by the respondents was that there are no defined, delineated geographical cities that are entirely saved for either GDC or KENGEN to do geothermal exploration. The two parastatals need to coordinate through blockchain adoption to accelerate targeted geothermal development and harmonize their cost of exploration.

The study established that GDC commissioned project implementation and steam supply agreements with independent power producers without the off-checkers participation. This went against the predefined agreement since KPLC should access and verify such agreements before concluding any power purchase agreements. The respondent agreed that blockchain's distributed digital ledger system would address such challenges.

4.3.6 Transmitter-Kenya Electricity Transmission Company (KETRACO)

KETRACO, a 100% state-owned power utility, is mandated to carry out the planning, development, operation, and maintenance of high-voltage power transmission lines. The respondents added that the parastatal is tasked to achieve regional interconnections of high voltage grids of at least 132kV. Consequently, Kenya is now in business with neighbouring Eastern African countries.

However, challenges of high start-up outlay, and momentous economies of scale have triggered the natural monopolization of the country's power transmission system. The study observed that the current situation where KETRACO and KPLC develops and operate the transmission system resulted in duplication of professional and labour resources. Unfortunately, the lack of adequate information limited the study to analysing the relative transmission cost between the two power firms.

The respondents mentioned that blockchain's smart contracts could strengthen the regulation and terms of operation, specifically in monitoring the efficiency of cost allocation and minimizing system losses. The study observed that the interdependence between KETRACO, KENGEN and KPLC must strictly comply with the pre-set project plans and targeted timelines. Blockchain adoption in ensuring this objective is met would greatly minimize disruptions in the power supply chain.

4.3.7 Distributor-KPLC & Lighting Company (KPLC)

The study sought to establish the roles and mandate of KPLC as a power transmitter and distributor where the Government owns 51% while private investors own 49% of shares. The respondents mentioned that upon the establishment of KETRACO in 2008, the focus of KPLC evolved to power distribution, supply, and retail of electrical energy. However, the respondent added that KPLC still owns, operates, and maintains the power transmission lines developed before the KETRACO. Additionally, all the mini-grids developed by REREC are operated by KPLC, making it a monopoly in the Kenyan electricity market whereby all power generators sign corresponding power purchase agreements with the off-checker. The respondents added that transparency in the development of such agreements would be achieved by blockchain adoption.

From the above findings, it can be deduced that there is a need for KPLC management to oversee the power purchase, successive distribution, and trade efficiently. However, the respondents mentioned that monitoring independent power producer contracts and administration has been inefficient. Through blockchain adoption, operational efficiency can be enhanced given its advantages of proof of work and proof of stake that comes with the technology. Additionally, the study noted that KPLC's strategic leadership and oversight need to be targeted towards improving the performance culture by holding management to account for results.

4.3.8 The Independent Power Producer- Orpower 4 Inc.

Orpower 4 Inc, a subsidiary of Ormat Technologies, is Kenya's largest independent power producer utilizing geothermal technology to generate clean energy. The respondents appreciated the advantages of blockchain adoption in designing, developing, constructing and operating geothermal power plants globally. Ormat has made tremendous efforts in utilizing modern technologies such as blockchain to continuously improve geothermal technology with key objectives of providing alternatives, flexibility, and optimally customized energy solution to its customers.

The respondents mentioned that Ormat has expanded its territory to more than thirty countries; commendably, all their power plants developed to world-class quality. Modern technologies such as blockchain have propelled Ormat's field analysis and resource delineation in achieving optimal power plant and equipment configurations.

Additionally, the respondent appreciated blockchain's flexibility to design tailor-made energy solutions and turnkey provisions that are unique to specific projects, geothermal resources, and environmental conditions. The respondent boosted that Ormat is one of the few global green companies to offer a such range of services and appreciated blockchain vertically integrated architecture with intensive applicability across the power industry's value chain.

4.3.9 Fintech Company- M-kopa Kenya limited

The respondents at M-kopa described the organization as one of the largest connected asset financing platforms utilizing blockchain technology to provide over a million unbanked customers with smart products and services. The respondent added that M-kopa identifies and fills the market gap where most credit companies demand credit history or collateral before approving transactions. Using innovative financing models, the fintech company offers instant product access that is connected to the internet of things (IoT). This has enabled the company to build customer ownership and offer flexible micro-payments gradually. The respondents mentioned that once the customer successfully pays all instalments for the product, a credit history developed gives the customer access to more products and services.

The respondents mentioned that M-kopa has taken advantage of disruptive technologies such as blockchain to remain competitive by diversification of its portfolio. For instance, using the company’s pay-as-you-go business model, the fintech provides cash loans, insurance services, satellite entertainment connectivity and clean cooking technologies. The respondent also praised the ongoing E-mobility venture financed by M-kopa, which is a peer-to-peer business platform between the fintech and other mobility companies such as Roam and Ampersand.

4.4 Potential Blockchain Applications in Kenya’s Power Sector

4.4.1 Cryptocurrency, Token, and Investments

The study established that the global energy marketplace is quickly adopting cryptocurrencies and energy tokens. The advantage that allocation and adoption of cryptocurrency attract investors with the highest stake in the sector has attracted the attention of most power generators. For instance, KENGEN can now be awarded more crypto units for their efforts to utilize the least carbon-intensive sources. Similarly, the respondents confirmed that the future model of the initial coin offering would employ cryptocurrencies as an instrument to raise funds.

Respondents were asked about the possibility of the power off-checker (KPLC) and the regulator (EPRA) adopting cryptocurrencies for electricity and energy payments. The response was that discussions are underway to implement the Energy Act (2019) on net metering. This concept will provide a new energy token platform for independent power producers to offset their power bills from the national grid using excess power generated at off-peak. This would be a practical blockchain application that would facilitate clean energy investments and asset co-ownership.

The study also sorts to know if prosumers would consider electronic payments in the form of bitcoins instead of fiat currencies and how advantageous this would be to them. The respondents confirmed that blockchain-enabled solutions reduce transaction fees and increase security. Additionally, the smart PPA contracts and Ethereum models supported by blockchains would automatically execute payments to prosumers while keeping track of immutable records transparently and legally. The respondents added that renewable power generated by KENGEN could be tokenized and traded via the blockchain platform in fiat currencies and cryptocurrencies. Overall, one notable concern by respondents is the overhead cost of implementing the cryptocurrency infrastructure, in addition to the long-run market acceptance of the advanced currency. The respondents were concerned about the long-term value and savings gained from cryptocurrencies in relation to fiat currency, especially the ability to practically recoup their investment outlay.

4.4.2 Blockchain in Metering and Data transmission

The participants were asked to identify and describe the infrastructure and regulations needed to integrate bitcoin payment into smart metering and electricity billing in Kenya. Respondents at KPLC mentioned that blockchain adoption would improve the operational efficiency of the distributor by automating the billing process for both power prosumers and distributors, thereby reducing the administrative cost currently incurred. The study observed that this would enhance the transparency of power charges given the ability of blockchains to enable traceability of power generated and utilized at every endpoint. Consequently, these initiatives would provide an opportunity for motivating behavioral transformation and demand responses.

The respondents appreciated blockchain's ability to facilitate real-time data transfer and verification within the Kenyan power sector. For instance, the respondent identified that there is an ongoing conversation to allow EPRA, the regulator accepts cryptocurrencies for energy and electricity transactions. This mode of payment could also be extended to gas, water, mobile data and rent payments via digital wallets provided by blockchain adoption.

The respondent at KPLC proposed the application of blockchain in power line inspections and maintenance. In the event of contingencies, action would be automatically decided and prompt the system to alert the maintenance team by phone on the repair actions. Such intelligent use of blockchains and disruptive technologies would sort the consistent power blackouts experienced in Kenya.

4.4.3 Digitization by IoT

The study investigated how blockchain adoption would enhance the operational efficiency of fintech companies providing smart pay-as-you-go products and services. The respondents at M-kopa mentioned that the company is employing blockchain features such as Peer-to-peer platforms that are GSM enabled to manage electric mobility and clean energy solutions.

The study established that M-kopa now sells electric motorbikes and smartphones that are incrementally paid off using customers' M-Pesa mobile payment. The motorbikes and smartphones are linked to an active digital ledger that enables and disables usability depending on the customer's credit. The respondents added that once the full payment as pre-defined is honored, the entire product ownership is transferred automatically to the customer. The study established that through adopting such technology, the company offers cash loans and hospital insurance services using mobile wallets. The respondents added that M-kopa is now fully embracing blockchain-based solutions that present transparency, real-time monitoring and expandability of their products and services.

KPLC respondent mentioned that the company had invited bids for developing a blockchain-based e-mobility network for charging stations in Kenya. The power distributor is interested in building a charging infrastructure where customers use M-Pesa and credit cards to make payments across a distributed network. The respondent added that e-mobility adoption is a new venture, with more than 1000 electric automobiles on Kenyan roads. Consequently, this would substantially reduce the carbon footprint and significantly combat global warming. The respondents added that through blockchain-based platforms, green and carbon trading certification would be efficient, reduce transaction costs, globally generate such markets, and prevent double-spending.

4.4.4 Blockchain and Grid management

The study investigated how blockchain adoption would settle power market imbalances and reduce production costs and time delays by minimizing back-office processes. The respondents at KPLC identified the possibility of remodeling supply to demand balance by improving the coordination between KENGEN and KPLC operations. This would be achieved through automated verification of grid equity and enhanced visibility of the distributed power stations in Kenya.

The participants added that to safeguard the grid from potential cyber-attacks, blockchain adoption would link the whole grid infrastructure, metering system, and data systems through distributed ledgers resulting in substantial datasets that are more secure. The respondents added that blockchain implementation would address stakeholders' credit risks and collateral requirements through vigorous risk management strategies and control structures that apply an algorithm-based trust model instead of a human-based trust model in decision-making.

4.4.5 Peer-to-Peer trading platforms

The respondents at EPRA mentioned that, in The Energy (Net-Metering) Regulations, 2022, the regulator, together with power industry stakeholders, is planning to adopt P2P blockchain transactions between renewable energy prosumers and the national grid. According to the respondents, upon adoption of the bill, solar panels and power storage devices will be part of the existing national grid and public finance. However, prosumers shall be obligated to pay KPLC interconnection costs incurred during their set-up. The respondents added that by using blockchain technology, the prosumers would be compensated for electrical power supplied to KPLC by gaining credit for every unit generated within a billing duration. Consequently, this would greatly enhance efficiency in business operations between the independent power producers and the local marketplaces.

The respondents at M-kopa identified quantum blockchain as an improvement of Proof of Works (PoW), evidenced by their current decentralized mobile application known as Bolt chargers which operate on a P2P trading platform. The E-mobility customers connected to the platform make payment via M-Pesa after successfully barcode scan to the Bolt charger, enabling charging of their electric motorbikes via the GSM system. Consequently, blockchain adoption by M-kopa in the e-mobility project has lowered production costs making the company achieve higher rates of return.

4.4.6 Decentralized power trading platforms

The respondents at EPRA mention that existing multivariate solutions in the decentralized power business platforms in Kenya should employ artificial intelligence, predictive analysis, and machine learning in addition to blockchain. The respondent added that, with net metering adoption, prosumers risk disrupting the existing structures of power markets, which would eventually cause grid defection. Blockchain adoption would help address this challenge by efficiently locally optimizing the power systems, thereby reducing the strain on existing power networks. The respondents were concerned about blockchain's limitations related to scalability and speed of adoption by all the power industry players in Kenya. For instance, the participants were concerned about making their commercially sensitive data open-accessed to all competitors, especially those that may not adopt the technology. However, the respondents appreciated that blockchain adoption would increase customers' awareness and decision making leading to enhanced competition.

4.4.7 Blockchain and General Management

The study investigated how blockchain would be relevant in managing other organizations' support functions in the Kenyan power sector. The respondents were asked to identify challenges and solutions that could be addressed by blockchain adoption in the management of Human resources, Finance, operations, supply chain and public relations. The respondent at M-kopa mentioned that blockchain had enhanced their payroll system through efficient identification and validation of their unbanked casual workers. The technology has dramatically reduced paperwork and enhanced the process of background checks during recruitment by tokenizing an applicant's particulars. The respondents at KENGEN added that employee data had been made secure by blockchain's trusted and reliable data input platforms that are then securely stored in distributed ledgers.

The participants from EPRA appreciated that some of their finance functions related to smart contract development and implementation could be optimized through cryptocurrencies to make digital payments. Leveraging blockchain would address the challenge of security bridges and enhance record-keeping, thereby addressing customer impersonation and supporting fraud detection.

Target respondents added that blockchain adoption in operations management would eliminate the need for third-party authorization through automated verification, given that pre-defined business requirements are met. The KPLC respondent confirmed that plans are underway to ensure that payments to suppliers are done from digital assets connected to their smart contracts. The participants at M-kopa appreciated that the modern supply chain is global, with enormous repercussions for errors and delays during product development. Consequently, blockchain has provided a platform that ensures safe editing and an efficient document transmittal process that is transparent and accountable and offers real-time monitoring to its globally distributed business players.

In reference to public relations, the respondents at M-kopa welcome the idea of employing blockchain to accurately identify and quantify potential online customers, given the challenges of hackers using robots for advertisements. The respondents added that blockchains could be used to get meaningful customer feedback that helps them improve their future product quality and trade processes. The study confirmed that blockchain adoption is disrupting the old advertisement structures used by improving its efficiency and effectiveness in marketing products and services to the target customers.

According to the respondents', modern accounting management has been impacted by blockchain technology. For instance, smart contracts that apply pre-set computer protocols rely on the old double-entry system and have now introduced a triple-entry accounting system that offers proof-of-work and protection to the distributed ledgers. Additionally, the respondents commented that a decentralized ledger brought by blockchains eliminates intermediaries from the transactions. Consequently, this provides better proof of works attached to the transactions reported in the financial statements, thereby giving more robust supporting evidence to the transactions made.

The management of transport and logistics' decentralized nature lends itself easily to blockchain technology. The study observed that the e-mobility industry generally comprises numerous drivers, passengers, vehicles, and a complex road network that are all decentralized and would highly benefit from blockchain adoption. For instance, the exclusion of a centrally controlled charging infrastructure for e-mobility, error tolerance, lack of price controls and conflicts between transport investors and the government would all be efficiently and effectively streamlined by blockchain adoption.

The respondents mentioned other notable applications of blockchains in other sectors, such as smart healthcare management. For instance, blockchain's distributed ledger technology supports secured transmittal of patient medical records, manages medicine's supply chain, and provides valuable data that assist researcher's root cause of complex genetic cryptography. Additionally, the technology would facilitate precise and customizable medical research receptiveness without compromising data security in achieving authentic interoperability. Consequently, this would strengthen the health information process across different hospitals globally, achieving effective healthcare delivery.

4.5 Measures of Operational Efficiency in the Power Sector in Kenya

The study sort to establish the how efficient the current operational processes and procedures in the Kenya’s power sector are. The target respondents gave the following feedback on each of the measures.

4.5.1 Reliability

The respondents at M-kopa mentioned that their products and services' reliability is pegged on a pre-defined product development process referred to as regression validation and testing. The blockchain-based procedure gives the broad roadmap of a project and identifies bugs, defects and limitations of the intended product using Microsoft tools such as visual studio and Notion. The respondent added that to ensure the product is reliable, engineering testing subjects the product to a defined stressful environment before finally introducing the product to the market to a few customers. Based on the sampled customers' feedback, product malfunctions would be returned to the product developers for re-evaluation and improvement. Consequently, blockchain enables the business to make informed investment decisions from the products' idea conception stage to the final mass production stage, thereby maintaining a high customer retention rate. Currently, in Sub-Saharan Africa, Kenya suffers from an energy crisis and socio-economic shortfalls. Accessibility to a reliable power supply is a real challenge that the current Government is objectively addressing through the ambitious plans defined in the Vision 2030 program. According to one of the respondents, Kenyan firms and industries suffer from power outages amounting to monthly losses averaging to Kshs. 6.3 million. Such power distractions cost these businesses about a 7.1% reduction in overall sales income.

4.5.2 Cost

The respondents were asked to identify how blockchain adoption in their production workflow could protect the sector's markup. The study established that the technology would enable the power sector industry players to reach commonality without intermediaries during complicated negotiations. The respondents added that through blockchain, complex contract transactions between all the players in the power sector could be accomplished in a trusted peer-to-peer way.

Targeted respondents identified blockchain-based energy performance indicators and automated control systems such as the supervisory control and data acquisition (SCADA) that identifies and monitors the main variables contributing to their facilities' power transmission inefficiencies, thereby reducing operation and maintenance costs. The respondents added that the high cost of grid power could be reduced by blockchain adoption through the real-time provision of power-saving equipment and accurate recording of power consumption of connected loads in immutable online ledgers.

Generally, the respondents appreciated that the power sector is a highly capital-intensive investment with between a seven to eight years gestation period and even demanding a more extended operation period of approximately 25 years before breaking even. Currently, the Kenyan power sector needs to streamline its cost management techniques to correctly determine power prices and tariff regulation. This could be achieved through the development of flexible cost allocation, efficient loss distribution and gap analysis that can be achieved by implementing multi-dimensional costing calculations and reporting. The respondents added that the technical losses arise due to overloaded distribution transformers and over-stretched low-voltage transmission lines coupled with low consumption levels. KPLC's overlapping functions of investing in power generation and transmission have thwarted efforts to improve the quality of the power network.

4.5.3 Transparency

The study sought to establish how blockchains would measure and enhance transparency in the Kenyan power sector. The respondents identified internal controls installed by their organizations to increase automation, accuracy, and predictability across their business processes and systems. For instance, at KPLC, blockchain facilitates the segregation of duties in an open ledger system involving accounts payable, ensuring that no individual is solely responsible for managing tasks with high bribery risks.

Targeted respondents identified smart meters as an efficient way of managing illegal energy connections. For instance, blockchain technology monitors the signals for terminal and gateway smart meters installed on every node of KPLC system feeders. Consequently, the smart system protects distribution lines by detecting illegal electricity connections.

The respondents also mentioned that blockchain in procurement provides a high level of transparency at all the supply chain stages. For instance, the technology keeps accurate records of all transactions and instantaneously updates all players. Additionally, the enhanced trust and transparency reduce operation costs for organizations since blockchain, coupled with cloud technology, eliminates tools that traditionally acted as intermediaries and lengthy third-party verification processes. More importantly, blockchain strengthens traditional procurement tools by making them more effective and reducing the costs of the supply chain processes.

4.5.4 Accuracy and Timeliness

The respondents identified the existing infrastructure and its efficiency in measuring and monitoring the balance between power generation and distribution. According to the respondents at EPRA, blockchain remains relevant in planning both medium- and long-term projects in Kenya's power sector. For instance, the respondent mentioned that the technology enables accurate analysis of demand forecast, load prediction, generation demand, quality of transmission network and modelling of future cost estimates of tariffs derived from the pre-defined plan. The study established that the demand forecast for power generators (KENGEN) and distributors (KPLC) is informed by socioeconomic and political factors. Additionally, the respondents mentioned that the power sector revenue obligations depend on cost forecasts predicted during power generation, transmission, and distribution.

The respondents added that the current state of Kenyan power generation has tripled following the baseload diversification from hydropower to geothermal power. However, planning failures have led to supply outpacing demand, thereby creating a surplus supply situation. While Kenya enjoys strong planning and procurement work plan, it is still a slave to political intrusions, which affects power demand projections, selection, and procurement procedures.

4.6 Constraints Encountered in Adoption of Blockchain Technology by the power sector

The study sought to establish the challenges hindering Kenya's power sector industry players from adopting blockchain technology. The participants identified challenges that broadly depict limitations in terms of blockchain's scalability and relevance to current business needs, security and ecosystem support demanded by the technology. The respondents mentioned that distributed ledger technology is still developing; therefore, the practical and long-term value is still opaque to most power industry practitioners.

The first constraint identified by the respondents was blockchain's speed, scalability and security demanded by the power industry. The participants appreciated the ongoing research efforts, especially on distributed consensus algorithms that form the backbone of this adoption. Nonetheless, the power industry needs significant trade-offs given that it is still impossible to coin a solution that meets all desired diverse objectives. The respondents noted PoW algorithms to be more secure and developed, even though their implementation is energy intensive and functionality speed is still slow. Consequently, PoS theory was identified as being faster, more scalable, energy-efficient and attractive to most blockchain developers. The respondents added that to enable parallel processing of enormous data, techniques such as 'sharding' would enhance the speed, though

this still reduces the technology's security and decentralization. The study, therefore, established that there is a need to have a clear strategic view during selecting the relevant consensus instruments and system architecture that meets the operational objectives of each power sector.

The respondents' second concern was security threats from poor system design and malfunction experienced at incubation stages with limited developer experience in large-scale blockchain implementation. The participants observed that blockchain ecosystems majorly depend on coding advanced algorithms, a process prone to omissions. Respondents also mentioned that bitcoin, the oldest distributed ledger technology implemented, is more resilient than Ethereum, which attracts severe threats from hackers. Notably, the study observed that cyber-security vulnerabilities are mainly caused by peripheral features such as smart contracts, whose security is critical in power system management.

The respondent identified the third constraint as the high development cost incurred by the distributed ledger technology implementation. Blockchains still need to prove their competitive advantage over existing smart solutions, such as telemetry currently applied in the established power markets. The participants observed that such conventional databases already available with lower operational costs give blockchains serious competition. However, the study observed that these cheaper solutions do not offer transparency and cannot eliminate the need for a trusted intermediary. The participants added that the integration of smart meters demands momentous computational strengths. This would require integrating grid infrastructure and smart meters with blockchain technology, which attracts significant costs. The respondents also added that blockchain systems attract additional costs of information verification and continuous data storage. However, this is recently being addressed by storing raw data using 'sidechains' while distributed ledger operation is carried out as a control layer instead of a storage layer.

The respondent mentioned the fourth challenge as fixed regulatory frameworks that need amendments to support the adoption of distributed ledger technology. For instance, the study observed that existing regulatory policies do not support and promote P2P power trading platforms. This demands that the smart contracts utilizing the public grid would protect the interest of both power prosumers and consumers through flexible electricity tariffs that are currently over-regulated. Generally, the respondents proposed that the current regulatory sector needs to integrate and reconcile functions of power generators, transmitters and distributors, thereby addressing the challenges of grid imbalances, central control integration and main grid coordination. According to the respondents, these constraints can be addressed by distributed ledger technology.

Finally, the study sought to establish timelines for when blockchains like Microsoft's excel would be widespread and what other disruptive technologies would accelerate the distributed ledger technologies adoption. The respondents, on average, agreed that, propelled by global challenges and opportunities brought by the scarcity of oil reserves and carbon trading attraction, by the year 2030, blockchain adoption will be rampant. One of the participants observed that disruption such as E-mobility heavily depends on blockchain infrastructure in both product development and operational efficiency. However, these challenges are not unique to the power sector since every industry player must evaluate and consider

blockchain's relevance to its core and supporting functions. It is imperative to appreciate the obstacles that arise from introducing such new ideas to organizations before making an informed decision on whether to adopt or reject blockchain technology.

4.7 Discussions on Findings

The relationship between the specific objectives was correlated with the literature review of this study. It was also possible to establish that the findings agreed with deductions made by previous researchers. The study's findings are analyzed below in comparison to the objectives. For instance, on the potential applications of blockchain technology towards enhancing operational efficiency in Kenya's power sector, the study established that distributed ledger technology is a promising disruption for a broad area of product and service management in the power sector. All the major industry players in Kenya's power sector, from generation, transmission, distribution and regulation, are currently involved in blockchain projects, evidenced by direct and indirect investments made, clearly depicting the potential importance of this emerging technology in the power sector.

According to Robu & Merlinda (2019), blockchain technologies still need to prove their scalability, speed and security before fully being adopted by the power sector. More research on the distributed consensus algorithm is needed to investigate the impact caused by blockchains, especially on the operational efficiency of Kenya's power sector. However, a golden solution that fuses all the desired attributes for every power industry player is far from being realized without allowing for consequential trade-offs. For instance, the study findings, in tandem with the System theory described in the literature review, showed that the Proof-of-Work (PoW) algorithms, though more mature and secure, are very slow and demand intensive energy outlay. Consequently, developers in blockchain are notably adopting the Proof-of-Stake (PoS) patterns that prove to be more energy efficient, more scalable, and faster to implement. The study established that implementing all four independent variables, that is, Peer-to-Peer trading platform, decentralized trading platform, imbalance settlement and digitization by IoT processes, highly influence the operational efficiency of the Kenyan power sector. Another practical solution applicable in the sector is the sharding technique that supports the parallel processing of data blocks. However, this demand for some trade-off on security and decentralization is unavoidable.

The study findings on the constraints facing the adoption of digital ledger technology by Kenya's power sector agreed with the recommendations by Eurelectric (2017). The two studies noted that blockchain faces security concerns stemming from poor system designs and malicious malfunctions at the conception stages. The fact that blockchain ecosystems, such as digital wallets and smart contracts, heavily depend on programmed algorithms that are prone to errors attracts security breaches which consequently discourages potential users in the power sector. The findings also agree with PWC (2016), who described the high development outlay demanded by blockchain implementation. The auditor, however, mentioned that blockchains might achieve significant cost savings by bypassing intermediaries with a trade on competitive advantages provided by existing well-established market solutions. The costly updated infrastructure, such as custom-made ICT facilities and support software demanded by the technology, should be worth the heavy investment made by the industry player.

The application of digital ledger technology through P2P trading platforms, according to Satoshi (2009), is still in the early development stages, and therefore their adoption scale is minimal. However, blockchains depict the potential to radically transform the existing mandates and responsibilities of Kenya's power industry layers from generation, transmission and distribution of power. Expressly, P2P markets and local grid systems would grant prosumers and consumers access to wholesale energy trading.

Additionally, regulatory authorities such as EPRA are mandated to set the rules ensuring consumer data protection. For instance, blockchain users in the Kenyan power sector should account for their liabilities and simultaneously protect commercially sensitive information, such as agreed power prices between the generator (KENGEN) and distributor (KPLC) within a smart contract recorded in a digital ledger. According to Tumino (2021), the information from multiple industry players recorded in shared ledgers demands data privacy, confidentiality, and identity management. Furthermore, smart contracts should have legal backing to ensure compliance with the Kenyan Law that protects both prosumers and consumers. With blockchain adoption, trust is bestowed upon the technology itself instead of a single authority.

4.8 Chapter Summary

In summary, distributed ledger technologies can highly benefit the markets and consumers in the Kenyan power system from generation, transmission distribution and regulation of power. Blockchain provides transparency, mediation-less, and secure transactions that offer novel solutions to the concerns of both prosumers and consumers in Kenya’s power sector. Blockchain adoption by the sector has introduced applications of the sharing economy in the power sector, thereby developing new market models that democratize the energy sector. Being the first-moving field of research, the technology calls for reviews to enhance understanding, build the body of knowledge and expose the potential application in all sectors of the economy. The study showed that most technology engagements are still in the incubation phase, with research still building on fundamental areas practically relevant to the power industry, specifically addressing the desired scalability, security, and decentralization of technology in addressing practical industry challenges. However, blockchain adoption is disruptive for the whole power sector and would attract equal resistance to realize notable market penetration. These include competition from existing technologies such as AI, big data, and legal and regulatory barriers that have been present for a while. Additional research initiatives coupled with the collaboration of key industry players in the power sector would eventually prove the commercial viability of blockchains and accelerate their full adoption in the power mainstream.

CHAPTER 5 : SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section captures a summary, conclusions, and recommendation on the influence of blockchain adoption to operational efficiency of the Kenya's power sector. In addition, the chapter outlines research limitations and the outlook of the study.

5.2 Summary of Findings

5.2.1 Objective 1: Potential Application of Blockchains in Kenya's Power Sector

The study established that distributed ledger technologies (DLT) lend itself in addressing existing operational challenges and business processes in the Kenyan power sector. A summary of Blockchain's potential applications include the following:

1. System and Process Transparency- Immutability and process transparency enhance system auditing and compliance regulation of all power sector industry players in Kenya.
2. Security and identity management- Cryptographic techniques enhances protection of transactions and privacy of data using blockchain platforms such as Ethereum, Hyperledger and Corda.
3. Competition Control- Blockchain's smart contracts could significantly streamline and fasten the process of switching power utility through provision of enhanced market mobility.
4. Shared Database- Electric motorbike (EV) charging infrastructure could benefit from blockchains decentralized management systems. The distributed market requirement in the EV industry demands for charger provisions to support multiple EV charging.
5. Grid management- Blockchains enable integration of flexible trading platforms and optimization of flexible assets, which could otherwise demand expensive network upgrade and maintenance costs.
6. Smart grid applications and Data transmission-Blockchains can be employed in machine-to-machine communication, data transmission and storage for smart devices such as smart meters, network monitoring and advanced sensory systems in the power sector.
7. Trade Processes and Marketing Platforms- Market operation management. For instance, the management of wholesale markets, transactions for commodity trading and risk considerations could be greatly enhanced by adoption of the technology.
8. Automation- Behind the meter activities such as net-metering that enables self-power production and utilization could be improved by blockchain adoption in the decentralized

power systems and microgrids. For instance, power markets supported by the limited P2P energy distribution and billing platforms.

9. Sales and Marketing- A combination of blockchains and Artificial intelligence (AI) methods such as machine learning enables the power distributor to correctly predict the consumer's energy patterns making then tailor-make the value-added power products and options.
10. Power Billing Management- Automated billing for the distributed generators and remote prosumers could be enhanced by blockchain's smart contracts and smart metering.

5.2.2 Objective 2: Measures of Operational efficiency in Kenya's Power Sector

The study endeavored to analyze five operational efficiency measures addressed by blockchain adoption in Kenya's power sector. According to the data analysis, reliability, cost, transparency, accuracy, and timeliness are quantum considerations that could be improved by distributed ledger technology. For instance, the study's findings established that reliability remained critical across all the power supply chain players based on observations that operational efficiency directly depends on the reliability of pre-defined cryptographic instructions. The study ascertained that cost of implementing blockchains by the power sector should be outweighed by advantages accrued by accuracy, transparency, improved security, and elimination of intermediaries.

5.2.3 Objective 3: Constraints facing Adoption of Blockchain in Kenya's Power Sector

The study sought to identify the challenges impeding full blockchain adoption by all the power sector industry players. It was evident that blockchain technology has passed the proof-of-concept stage for most adopters. However, to achieve operational efficiency, there is a need to enhance speed, scalability, and security levels, especially during the incubation phases. Additionally, the high implementation cost of distributed ledger technologies and rigid regulatory frameworks throttle the full adoption of blockchains by Kenya's power sector. The study established that this could be addressed by standardization and flexibility of blockchain architecture to ensure interoperability with other disruptive technologies such as artificial intelligence and big data analytics.

5.3 Conclusion

The study exposed how distributed ledger technologies such as blockchains contribute immensely to improving operational efficiency in Kenya's power system operations, specifically for the power generators, transmitters, distributors, regulators and FinTech's. While considering the measures of efficiency visa vie blockchain features, the study concludes that investment in distributed ledger technology is profitable and sustainable in the long run.

The study concluded that blockchain technology offers transparency, tamper-proof transactions and eliminates the need for trusted intermediaries. However, but necessary to note that blockchain adoption brings on board the interests of prosumers, customers, and shareholders on one platform. Additionally, the technology has nurtured sharing-economy applications in Kenya's power sector, prompting the interests of all the industry players and democratizing the whole supply chain.

The study showed that blockchain adoption by Kenya's power sector is in an incubatory phase, with ongoing research tailored towards achieving desired security, scalability, and complete decentralization. The study also appreciated that distributed ledger technologies could be disruptive, especially for emerging power investors trying to achieve market penetration and forced to deal with numerous regulatory, legal and competition barricades. In summary, additional research and leadership by Government and power industry players in Kenya could enable blockchain's full utilization, prove its commercial viability and thereby catalyze its acceptance to the power sector's mainstream.

5.4 Limitations of the Study

The study was limited to Kenya's power sector only. It is possible to integrate the petroleum sector, which directly influences the power sectors' operational efficiency and all other affiliated power production and utility players.

Time constraints due to some respondents' tight work schedules hindered the face-to-face interview guide's administration to capture accurate screening of emotions and verbal cues. This would have facilitated capturing non-verbal cues such as body language and discomfort with the interview.

5.5 Recommendations

The study recommends the following:

1. Elimination of the permanent monopoly enjoyed by the power distributor (KPLC). Adoption of a distributed generation system as opposed to the current centralized grid would bring positive competition in the power sector. Consequently, this would enhance quality distribution of electricity throughout the whole country as targeted in vision 2030.
2. Immediate full adoption of distributed ledger technologies such as blockchains in the operations management of the power sector. This would address both the large technical and commercial losses currently accrued. Specifically, the technical losses are consequences of operational inefficiencies in power transmission and distribution from the generation stations to the customers. Commercial losses on the other hand result from power thefts at the

customers’ end point. The illegal connections for both large power consumers and SMEs especially at informal settlements contributes to such system losses.

5.6 Suggestions for Further Research

The study suggests more research focused on addressing the high cost of power despite Kenya being endowed with numerous renewable energy resources and the government's goodwill to invest in power generation projects. Further research can be carried out to undertake an in-depth review and analysis of contractual agreements between the Government and independent power producers while making both profitability and customer interests the center of attention.

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APPENDIX 1

Interview guide

This interview guide seeks to measure the awareness, impact and potential applications of Blockchain Technology and Operational Efficiency in Kenya's power sector.

Your contribution will be highly appreciated and treated with utmost confidentiality.

Section 1: General Information

I. Name of your company: …………………………………………….

II. In the Kenya's power sector supply chain process, please categorize your company by ticking.

i. Generator [ ]

ii. Transmitter [ ]

iii. Distributor [ ]

iv. Regulator [ ]

v. Fintech [ ]

III. The position your hold in your company:

Head of Department [ ]

Manager [ ]

Engineer [ ]

Information Technologist [ ]

Logistics Officer [ ]

Any Other …………………………………………….

Section 2: Potential applications of blockchain technology in Kenya's power sector.

1. **Mandate and responsibilities**: Who are the key stakeholders in the power sector? What are the formal/informal roles and responsibilities of the different power industry players? Is there a demand-to-supply balance between power generation and power utility in Kenya?
2. **Cryptocurrencies, token, and investments:** What is the likelihood of the power off-checker accepting cryptocurrencies for electricity and energy payments? Which industry players are flexible to accept payments for energy bills in the form of bitcoins? Will prosumers accept to execute payments electronically by automatically exchanging bitcoins to say, dollars? What incentives will prosumers gain upon adopting bitcoin

instead of fiat currencies. Could savings be collected and stored in form of cryptocurrencies depending on prosumers choice?

3. **Metering and data transportation:** What infrastructure is required to integrate bitcoin payments into smart meters? Describe the regulatory policies demanded on cryptocurrency to enhance their application by the Kenyan power sector. How would smart contracts and automated transactions enable real time data transfer and verification between the power industry players and their customers?
4. **Digitization by Internet of Things :** How can blockchain technologies support pay-as-you-go solar services and E-mobility in Kenya by utilizing M-pesa platform?
5. **Grid management and imbalance settlement:** How can blockchain technology assist in the settlement of power markets imbalances in Kenya? Do you think blockchain could undercut production costs and minimize time-delays by reduction of back-office processes? How can the power market be more transparent and efficient thereby reducing stakeholder's credit risks and collateral requirements?
6. **Human Resource management**

In your organization's Human resource management system, can blockchain enhance payroll through efficient identification and validation of unbanked personnel before making direct mobile money payments? In your recruitment process, could blockchain reduce paperwork and increase the speed for background checks through tokenizing a candidate identity and virtual particulars such as transcripts and resumes? How can blockchain enhance your security to minimize internal and external financial fraud and protect employee data by ensuring that employee records cannot be changed or accessed by unauthorized persons?

7. **Financial Management**

Could some finance functions such as smart contracts implementation and digital payments through cryptocurrency be optimized by blockchains in your company? Do you think the challenges of security bridges and corrupted record-keeping be addressed through blockchain adoption? Can your organization leverage on blockchain to enable secured cross border payments using existing cryptocurrency-based products? Do you think banks and transaction institutions could employ blockchain in customer identity management and fraud detection?

8. **Operations Management**

Blockchain eliminates the need for third-party confirmations, how can this enhance business operations by automatically verifying and executing pre-defined company procedures in you organization? Can your company employ blockchain to monitor progress of works, verify and enforce terms of contracts. How can your organization ensure that payment to suppliers is automatically done from the digital assets connected to the smart contract?

9. Supply Chain Management

Modern supply chain processes are global, where an error in the interconnected activities generates multiple losses to organizations. How nan blockchain adoption in your company ensure transparency, accountability and real-time inspections? Can blockchain be implemented to ensure efficiency in the global logistics through safe edit and transmission of supply chain documentations?

10. Public Relations Management

To accurately quantify online followers, do you think blockchain could be employed to audit online mentions thereby ensuring that only real followers instead of robots are behind every like and share of company adverts? How can your company use blockchain to get valuable customer feedback that could help improve the quality of its product and services. Can blockchain disrupt the old architecture of advertising models?

11. Accounting Management

Do you think adoption of blockchain technology would disrupt all recordkeeping procedures and norms of initiating, processing, authorizing, recording and reporting transactions in financial statements? How would blockchain adoption impact back-office activities such as tax preparations? What changes would blockchain bring to both roles and skill sets of accountants? Would this transform the methods of obtaining audit evidence by considering both blockchain ledgers and traditional stand-alone ledgers?

12. Peer-to-Peer trading platforms

How can net metering enhance businesses efficiency between local marketplaces and independent power producers? What is the interest of prosumers in the local marketplace and how can such markets be integrated in the existing Kenyan grid to enhance operational efficiency and effectiveness? In the domestic power pricing, how can blockchain help in elimination of universal subsidies, lower production costs and achieve high rates of return? What energy efficiency measures on the demand side management can be improved using blockchains to improve public finance?

13. Decentralized power trading and utility

What flexible multivariate solution for decentralized blockchain solutions could help unify power generators, consumers and utilities at diverse applications thereby enhance operational efficiency?

How could blockchain and data science be applied to smart metering systems and energy billing to improve operational efficiency?

Section 3: Measures of operational efficiency of the power sector in Kenya.

I. Reliability

How do you measure reliability of your product and services in the power sector? How accurate are your measurements in response to your customer's diverse energy needs? How reliable is your contribution across the different zones and usage? What is your customer retention rate for the past 5 years? Do you think blockchain adoption would enhance your reliability?

II. Cost

How do you ensure that your cost of production is minimized without jeopardizing on the quality of your product and services? What energy performance indicators and baselines do your organization use to control cost of production? Do you think automation such as SCADA system would minimize your operational cost? How would blockchain adoption reduce your maintenance cost? What challenges contribute to high cost of grid power compared to off-grid power? Which levies can be dropped to reduce per unit cost power?

III. Transparency

How is organizational transparency measured? Do your organization assure clarity, trust and accountability to its stakeholders? What systems are employed by your organization to mitigate corruption and scandals? Could smart metering detail bribery and illegal connections? How would blockchain adoption support these initiatives?

IV. Accuracy and Timeliness

How accurate are your energy measurements and monitoring plan to ensure a balance between your power demand and supply? Coordination between power generation, transmission and distribution is essential, how accurate is your organization ensuring that this balance is maintained? How optimal are your operation schedule in reference to the P2P markets? How would blockchains assure sustainability of such a market?

Section 4: Constraints facing adoption of blockchain technology in Kenya's power sector.

As a power sector industry player, what are the challenges hindering your organization from adopting blockchain technology?

What else can you share about blockchain? Do you have any fears toward its adoption? If yes, what are your concerns? Which year approximately do you think blockchain will be widespread like word and excel? What other technology platforms would accelerate blockchain adoption?

………………………………………………………………………………………

THANK YOU FOR YOUR EFFORT