Impact and Challenges of Introducing Blockchain Technology in Procurement and Supply Chain Management for Power Transmission Utilities: A Case Study of Power Grid Bangladesh PLC

By

Taufique Alam
ID No. 24382037

A thesis submitted to the BRAC Institute of Governance and Development in partial fulfillment of the requirements for the degree of
Master in Procurement and Supply Management

BRAC Institute of Governance and Development
BRAC University
July, 2025

Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

Student's Full Name & Signature:

_____

Taufique Alam
24382037

Approval

The thesis/project titled "Impact and Challenges of Introducing Blockchain Technology in Procurement and Supply Chain Management for Power Transmission Utilities: A Case Study of Power Grid Bangladesh PLC" submitted by

1. [Student-Taufique Alam (24382037)]

of Summer, 2024 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master in Procurement and Supply Management on 22nd July, 2025.

Examining Committee:

Supervisor:
(Member)

_____
Md. Hasan Maksud Chowdhury
Assistant Professor, BRAC Business School
BRAC University

Program Coordinator:
(Member)

_____
Mohammad Sirajul Islam
Senior Academic Coordinator
BIGD, BRAC University

External Expert Examiner:
(Member)

_____
Dr. Amitabha Chakrabarty
Professor, Computer Science and Engineering,
BRAC University

Departmental Head:
(Chair)

_____
Dr. Imran Matin
Executive Director
BIGD, BRAC University

Ethics Statement

I, Taufique Alam, hereby declare the following with regard to my participation in this research study:

- I confirm that my participation in this study, titled *"Impact and Challenges of Introducing Blockchain Technology in Procurement and Supply Chain Management for Power Transmission Utilities:* A Case Study of Power Grid Bangladesh PLC*"* has been conducted with full compliance and understanding of the ethical guidelines provided.
- I understand that participation in this research involves providing insights on the topic and contributing to the study through my experiences and knowledge.
- I affirm that I have maintained the highest level of integrity, honesty, and transparency throughout the entire research process.
- I acknowledge that there are no direct benefits or rewards associated with participating in this research.
- I pledge to ensure the confidentiality of all information collected and presented in this study, adhering strictly to ethical research standards and applicable regulations.
- I concur that the research has been conducted meticulously, with thorough analysis and the best use of time and resources available to me.
- I understand and respect my right to access information collected during this study as per the provisions of the applicable freedom of information laws.
- I am aware that I can contact any of the researchers for further clarification or information without any expectation of reimbursement.

Abstract/ Executive Summary

This thesis explores the impact and challenges of introducing blockchain technology into procurement and supply chain management within power transmission utilities, focusing on Power Grid Bangladesh PLC as a case study. Given the limited existing research, an exploratory research methodology was adopted to investigate the current state of blockchain adoption, its potential impacts, and the specific challenges faced by power transmission utilities. Blockchain is recognized for enhancing transparency, security, and efficiency in procurement, particularly in critical infrastructure sectors. The research identifies opportunities for blockchain, such as reducing fraud, increasing data security, and securing confidential procurement information vulnerable to cyber-attacks. However, challenges such as technical readiness, organizational resistance, and regulatory barriers are also addressed. This thesis proposes actionable steps for Power Grid Bangladesh PLC to adopt blockchain in procurement, highlighting its long-term potential for sustainability, continuous improvement, and operational efficiency in the energy sector.

Keywords: Blockchain; Data Security; Cyber-security; Transparency; Fraud Prevention; Power Transmission Utility.

Acknowledgement

First and foremost, I am profoundly grateful to Almighty Allah for His continuous blessings and guidance throughout my life and this research journey. His mercy and wisdom have given me the strength and perseverance to successfully complete this thesis.

I would like to express my deepest gratitude to my thesis supervisor, Mr. Hasan Maksud Chowdhury, Assistant Professor, BRAC Business School, Brac University, for his invaluable guidance, encouragement, and support. His expertise and constructive feedback have been instrumental in shaping the direction and quality of this work. I am truly fortunate to have his mentorship throughout this process.

I am also immensely thankful to my parents, whose unwavering love, prayers, and support have been my greatest source of strength. Their encouragement and belief in my abilities have been a constant motivation in achieving my academic goals.

Furthermore, I extend my heartfelt appreciation to my colleagues at Power Grid Bangladesh PLC. Their cooperation and assistance were crucial in collecting data related to the equipment procured by transmission utilities, which formed an integral part of this research. Without their support and insights, this study would not have been possible.

To all who have contributed in any way to the successful completion of this thesis, I am deeply grateful.

Table of Contents

List of Figures

List of Acronyms

NLDC	National Load Dispatch Center
IT	Information Technology
SCADA	Supervisory Control and Data Acquisition
SCM	Supply Chain Management
PoW	Proof of Work
PoS	Proof of Stake
P2P	Peer-to-Peer
B2B	Business-to-Business
DeFi	Decentralized Finance
e-GP	Electronic Government Procurement
CPTU	Central Procurement Technical Unit
ESS	Electronic Signature Service
PPP	Public-Private Partnership
IoT	Internet of Things
AI	Artificial Intelligence
PLC	Public Limited Company
EHR	Electronic Health Records
IPP	Independent Power Producers

JICA	Japan International Cooperation Agency
ADB	Asian Development Bank
EMS	Energy Management System
NTTN	Nationwide Telecommunication Transmission Network
BERC	Bangladesh Energy Regulatory Commission
KPI	Key Point Installation
BPDB	Bangladesh Power Development Board
DPDC	Dhaka Power Distribution Company Ltd.
DESCO	Dhaka Electric Supply Company Ltd.
REB	Rural Electrification Board
WZPDCL	West Zone Power Distribution Company Ltd.
EPC	Engineering, Procurement, and Construction

Chapter 1

Experience in the Organization

1.1 Role and Responsibilities at Power Grid Bangladesh PLC

I have been working at the National Load Dispatch Centre (NLDC) under Power Grid Bangladesh PLC as an Engineer (Power System Engineer) for several years. My responsibilities primarily involve real-time coordination among generation, transmission, and distribution utilities to ensure reliable and uninterrupted power transmission throughout the country. This includes maintaining power quality, monitoring grid stability, dispatching generation units, managing outages, and responding to emergencies such as system disturbances and blackouts.

As part of a highly critical operational division, I also contribute to short-term system planning and power system modeling, which are essential for secure and optimized grid performance. I regularly generate detailed operational reports and assist in maintaining compliance with the Electricity Grid Code, 2023, which sets the framework for grid operation standards in Bangladesh. These reports form the basis for both internal decision-making and external regulatory audits.

Over the years, I have also been involved in several collaborative initiatives with technical experts and consultants from both national and international organizations. These include engagements with agencies such as Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Boston Consulting Group, United States Trade and Development Agency, United States Agency for International Development and Monenco Consulting Engineers, working on operational improvements, standard operating procedures, reviewing Grid Code, digital transformation roadmaps, renewable energy management etc. Such exposure has broadened my understanding of global best practices in system operation and infrastructure modernization.

Importantly, I am also involved in procurement-related activities within my office, particularly in areas linked to system upgradation, software tools, and server-related equipment. These activities are often technical in nature, requiring a clear understanding of operational needs, technical specifications, and compatibility with existing systems. My responsibilities include participating in technical specification development, reviewing

vendor documentation, validating project deliverables, and providing operational feedback during procurement evaluations. I also monitor post-installation performance and provide feedback to the procurement team on supplier quality and compliance. This hands-on exposure has allowed me to better understand how procurement decisions are made in a technically sensitive environment like power transmission, and how delays or mismatches can directly impact operational efficiency.

As digital tools and platforms become more embedded in system operation, the importance of coordinated procurement especially in software and IT infrastructure has grown significantly. I regularly coordinate with IT teams, SCADA engineers, and the procurement officials to align technical requirements with procurement scopes. This has positioned me in a unique role where I act as a bridge between operational needs and procurement execution.

1.2 Relevance to Procurement and Supply Chain Management

The tasks I perform have increasingly intersected with procurement and supply chain management functions. While my role is operational in nature, many of the assets and systems I work with such as servers, software tools, communication modules, load dispatching tools, and IT platforms are acquired through structured procurement processes. I have seen firsthand how procurement planning, supplier evaluation, contract execution, and documentation management influence operational outcomes and continuity of service.

My engagement with procurement does not merely stop at providing technical input. In several instances, I have been part of the teams reviewing vendor proposals, providing remarks on technical compliance, and participating in meetings where procurement timelines and resource allocations were discussed. These experiences have helped me apply several key concepts from my academic background, including risk assessment in sourcing, vendor selection frameworks, and the need for structured procurement documentation.

I have also observed how project execution often depends not just on technical suitability but also on how well supply chain activities are coordinated across departments. For instance, equipment delivery timelines, contract milestone compliance, and responsiveness to change requests are key factors that determine project success. Delays in procurement due to approval bottlenecks or unclear specifications can lead to operational disruptions, particularly in areas involving SCADA systems or real-time communication modules.

This level of exposure has provided me with a more practical understanding of how procurement and supply chain decisions affect not only system performance but also regulatory compliance, customer satisfaction, and inter-agency coordination. It has made me more aware of the critical link between procurement efficiency and national grid reliability.

1.3 Reflection on Academic Knowledge and Reality

My academic learning in procurement and supply chain management gave me a solid foundation in procurement strategy, digital integration, vendor selection, and risk management. It introduced me to theoretical models for structured sourcing, e-procurement systems, contract lifecycle management, and the benefits of emerging technologies such as blockchain. However, my experience at Power Grid has shown that the real-world application of these concepts requires significant adaptation to the complexities of public sector operations.

For example, procurement processes in theory emphasize openness, efficiency, and standardization. In practice, I have encountered situations where confidentiality and technical precision take precedence particularly when dealing with critical infrastructure, sensitive data systems, or software-based control tools. Procurement delays caused by procedural complexity, inter-departmental communication gaps, or incomplete vendor submissions are also common challenges that are underexplored in academic texts. Moreover, documentation is often duplicated or inconsistent across units, and digital tools are not always integrated or user-friendly, which increases the burden on both technical and procurement staff.

I have also found that while academic models advocate for automation and transparency, public sector procurement must often balance these goals with security, compliance, and political accountability. For example, information about SCADA upgrades or software licenses may be classified due to their role in national infrastructure. This adds another layer of complexity that academic frameworks do not always address.

Despite these limitations, my background in procurement studies has helped me identify gaps and potential solutions. I have been able to assess where policies fall short, understand where digital tools can be improved, and recognize the benefits of introducing more advanced technologies like blockchain. In particular, blockchain's potential for improving transparency,

ensuring data immutability, and automating compliance processes seems highly applicable to the procurement challenges I have witnessed.

This thesis is a direct outcome of these reflections. It aims to bridge the gap between academic theory and institutional practice, particularly in public utility procurement. Through this study, I hope to offer practical insights and strategic recommendations that align technological innovation with operational realities.

Chapter 2

Overview of Power Grid Bangladesh PLC

2.1 Company Profile

Power Grid Bangladesh PLC, commonly referred to as Power Grid, was formerly known as Power Grid Company of Bangladesh Ltd. (PGCB), is the sole state-owned enterprise entrusted with the nationwide transmission of electrical power in Bangladesh. Established in 1996 under the Companies Act 1994, the organization plays a pivotal role in strengthening and expanding the country's electricity transmission infrastructure. As the central transmission utility, Power Grid functions as the intermediary between power generation entities and distribution companies, transmitting electricity through its high-voltage network across the nation.

Power Grid Bangladesh PLC is tasked with the planning, development, operation, and maintenance of the national transmission grid. The company's activities align with its declared vision and mission:

- **Vision**: Economic upliftment of the country by reaching electricity to all through reliable transmission.
- **Mission**: Efficient and effective management of the national power grid for reliable and quality transmission of electricity throughout the country.

Over the decades, Power Grid has developed a robust and wide-reaching transmission network comprising 400 kV, 230 kV, and 132 kV lines and substations. The company initially acquired assets from the Bangladesh Power Development Board (BPDB) and Dhaka Electric Supply Authority (DESA), including approximately 2,497 circuit kilometers of 230 kV lines, 4,236 circuit kilometers of 132 kV lines, and a number of substations at various voltage levels.

As of December 2024, the company's operational infrastructure includes:

- **Transmission Lines**:
    - 2,497 circuit kilometers of 400 kV lines
    - 4,265.5 circuit kilometers and 27.3 circuit kilometers (others) of 230 kV lines
    - 8,685.1 circuit kilometers and 236 circuit kilometers (others) of 132 kV lines

- **Substations**:
  - 1 × 400 kV HVDC back-to-back station
  - 8 × 400/230 kV substations
  - 4 × 400/132 kV substations
  - 29 × 230/132 kV substations
  - 1 × 230/33 kV substation
  - 134 × 132/33 kV substations

This infrastructure enables Power Grid to dispatch bulk electricity across the nation, playing an essential role in ensuring uninterrupted, quality power delivery and facilitating regional interconnection with neighboring countries such as India.

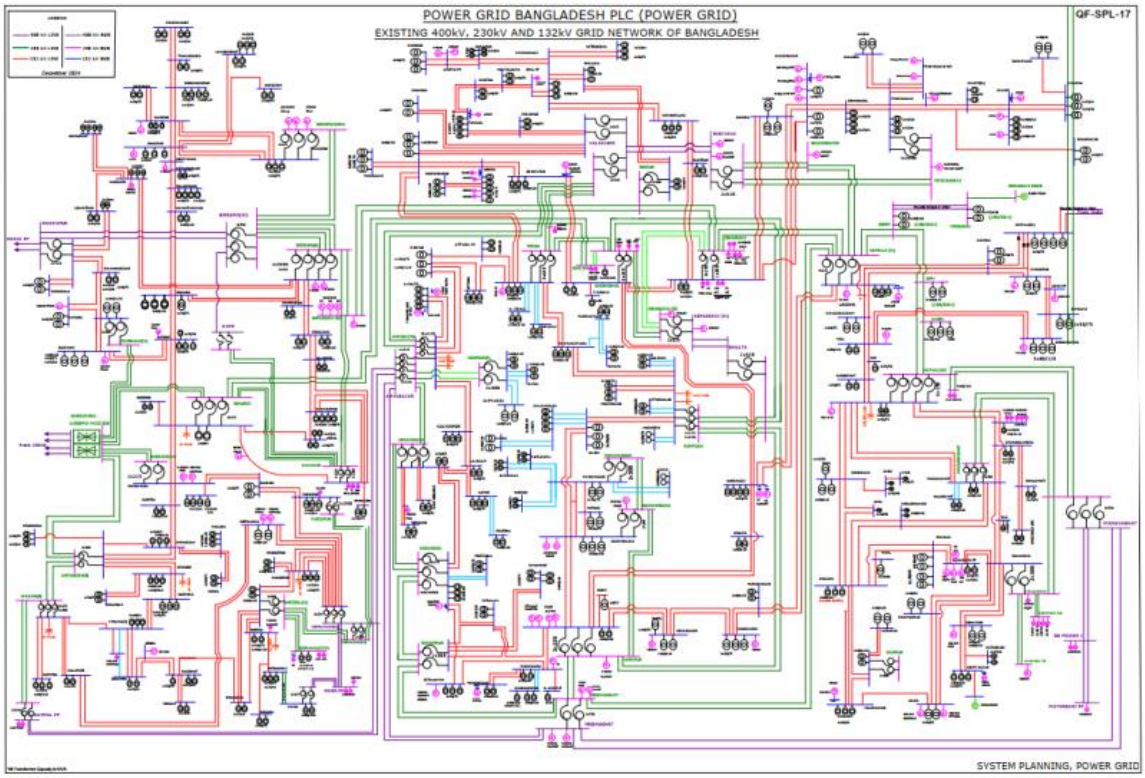

Figure 1: National transmission network of Power Grid

In addition to managing the physical transmission infrastructure, Power Grid also operates the National Load Dispatch Centre (NLDC) which is the heart of Bangladesh's electricity transmission system. The NLDC is responsible for real-time monitoring, scheduling, and dispatching of electricity across the grid to ensure a stable and balanced power supply. It performs critical functions such as load forecasting, generation scheduling, real-time grid

supervision, voltage regulation, frequency control, and outage coordination. The NLDC utilizes advanced Energy Management System (EMS) and SCADA software and hardware platforms, which provide real-time data analytics, automation, and control over grid assets. These systems are not only central to operational reliability but also represent a significant portion of Power Grid's high-value, technology-driven procurement requiring secure sourcing, specialized vendors, and robust technical specifications.

Power Grid's engagement with complex software and hardware systems like SCADA and EMS further highlights its role as a technologically advanced utility, with procurement decisions that directly impact grid performance and national energy security.

In addition to its core operational mandate, Power Grid also manages a fiber-optic communication network along its transmission routes, leasing bandwidth to telecommunications providers such as Grameenphone**,** Fiber@Home**,** Summit Communications etc. The company is governed by a Board of Directors and maintains ISO certifications for quality management (ISO 9001:2015) and occupational health and safety (ISO 45001:2018), reinforcing its commitment to operational excellence and regulatory compliance.

Given Bangladesh's growing demand for electricity, Power Grid continues to serve as a cornerstone in the realization of national development targets, including Vision 2041, which aspires to deliver universal access to electricity and establish a reliable, digitized power system capable of integrating renewable energy and smart grid technologies.

2.2 Functional Role of Power Grid in the National Electricity Ecosystem

The power sector in Bangladesh is structured into three main segments: generation, transmission, and distribution. Electricity generation is carried out by a combination of public entities such as the Bangladesh Power Development Board (BPDB), Ashuganj Power Station Company Ltd., and North-West Power Generation Company Ltd. and private Independent Power Producers (IPPs), which collectively contribute to meeting the country's growing energy demand.

Distribution responsibilities are divided among several public sector companies, including the Dhaka Power Distribution Company (DPDC), Dhaka Electric Supply Company (DESCO),

Rural Electrification Board (REB), and West Zone Power Distribution Company Ltd. (WZPDCL). These entities manage power delivery to residential, commercial, and industrial consumers across various geographical zones.

At the center of this tripartite structure is Power Grid Bangladesh PLC, which serves as the sole entity responsible for high-voltage electricity transmission across the national grid. Power Grid acts as a critical interface between generation and distribution, ensuring that electricity produced by both public and private generators is efficiently delivered to distribution utilities across the country.

The company is entrusted with maintaining system reliability, power quality, and grid stability functions that are particularly essential for a developing economy experiencing rapid industrialization and urbanization. One of the key operational arms of Power Grid is the National Load Dispatch Centre (NLDC), which performs real-time load dispatch, system monitoring, and scheduling of generation units. The NLDC continuously communicates with both generation and distribution utilities to ensure real-time supply-demand balancing, which is vital for power quality enhancements and avoiding blackouts, voltage drops in the power system.

In addition to its operational responsibilities, Power Grid contributes significantly to infrastructure development and policy execution in the power sector. The company collaborates closely with the Ministry of Power, Energy and Mineral Resources, the Bangladesh Electricity Regulatory Commission (BERC), and donor agencies such as the World Bank, Asian Development Bank (ADB), and Japan International Cooperation Agency (JICA) for the planning and implementation of grid modernization, automation, and expansion projects. In summary, the functional role of Power Grid Bangladesh PLC is not merely technical; it is strategic and systemic, placing the organization at the very core of Bangladesh’s electricity value chain and national development trajectory.

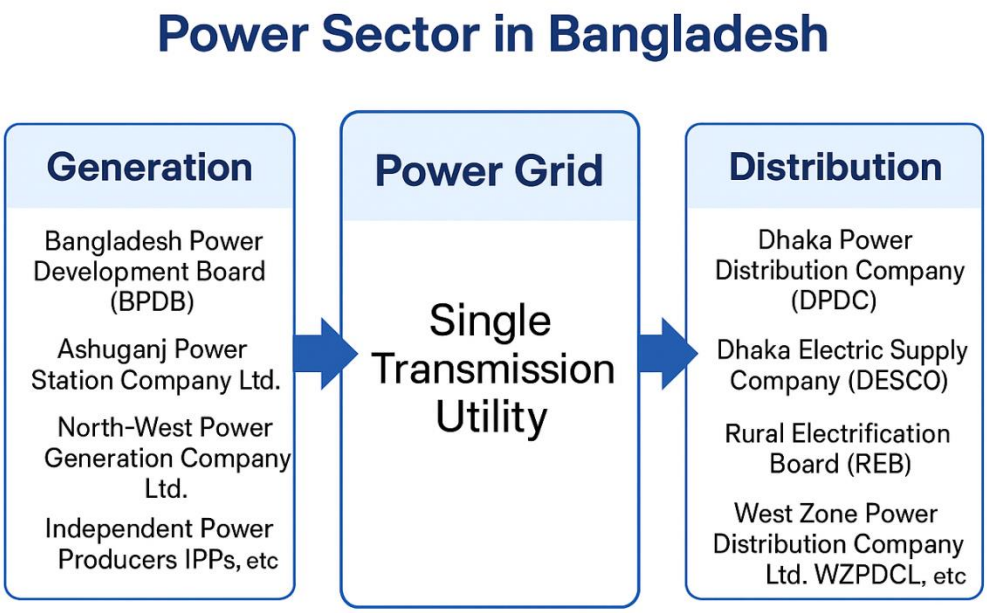

Figure 2: Structure of Power Sector in Bangladesh

2.3 Financial Operations of Power Grid

Power Grid Bangladesh PLC operates under a regulated financial model governed by the BERC, which determines the structure of energy wheeling charges which is the primary source of the company's revenue. These charges are levied on distribution utilities for the use of Power Grid's high-voltage transmission infrastructure. Revenue is collected from state-owned distribution entities such as DPDC, DESCO, REB, WZPDCL, and also from direct industrial off-takers connected at high voltage levels.

In addition to wheeling charges, Power Grid generates supplementary income through leasing its nationwide fiber-optic communication infrastructure to telecommunication providers such as Grameenphone, Fiber@Home, and Summit Communications. These leases fall under the Nationwide Telecommunication Transmission Network (NTTN) licensing regime and offer a commercial revenue stream alongside the company's core utility functions.

On the expenditure side, Power Grid allocates substantial capital towards the construction, upgradation, and maintenance of transmission infrastructure. This includes procurement of high-value assets such as transformers, circuit breakers, SCADA/EMS systems, tower structures, and conductors, along with EPC services. Operational expenditures include system

maintenance, staff salaries, IT systems, energy dispatch operations, and compliance with environmental and social safeguards.

To meet its capital investment needs, particularly for large-scale grid expansion and modernization projects, Power Grid secures financing from both domestic and international sources. Key development partners include the World Bank, Asian Development Bank (ADB) and Japan International Cooperation Agency (JICA). These funds are typically disbursed through government-to-government credit arrangements or project-specific loan agreements, and are subject to strict procurement, environmental, and reporting guidelines as stipulated by each donor agency.

2.4 Existing Procurement and SCM Practices

The Power Grid Bangladesh PLC, as the primary entity responsible for the country's power transmission infrastructure, handles large-scale procurement activities tied to both development and maintenance projects. Power Grid's procurement practices are guided by the Public Procurement Rules (PPR) 2008, supplemented by funding agency guidelines such as those from the World Bank, ADB, and JICA for donor-financed projects. These rules ensure a competitive, fair, and transparent process, but they are also procedural, time-intensive, and heavily reliant on documentation.

Procurement activities in Power Grid typically follow a multi-stage process: need assessment, technical specification preparation, tendering, bid evaluation, approval, contracting, delivery, inspection, and payment. For high-value items like power transformers, protection relays, and transmission towers, the cycle often extends across several months. Delays can occur due to bureaucratic approvals, inconsistencies in documentation, supplier-side inefficiencies, or external factors such as currency fluctuations and customs clearance.

Supply Chain Management (SCM) within Power Grid also faces limitations due to its semi-digital nature. Another challenge lies in managing supplier relationships and ensuring quality assurance across geographically dispersed project sites. Power Grid often works with both local and international suppliers, which increases complexity in logistics, compliance, and after-sales support.

Despite the structured approach, current systems lack real-time visibility, end-to-end traceability, and strong data security mechanisms, especially for sensitive or classified

purchases related to Key Point Installations (KPIs). This creates an opportunity for improvement through the adoption of secure and transparent technologies like blockchain, which can address many of the pain points in Power Grid's procurement and SCM processes.

2.5 Current Level of Digitalization in Procurement

Power Grid Bangladesh PLC has made notable progress in digitalizing its procurement processes, aligning with the government's broader agenda for transparent and efficient public procurement. A significant step in this direction has been the adoption of the Electronic Government Procurement (e-GP) system, which Power Grid now actively uses for tendering, especially for projects funded by the government or development partners.

The e-GP platform, managed by the Central Procurement Technical Unit (CPTU), enables online publication of tenders, submission of bids, bid evaluation, and contract award notifications. This has improved accessibility for bidders, increased competition, and enhanced transparency. Most routine and non-sensitive procurement activities are now handled through e-GP, reducing paperwork and standardizing tender procedures.

However, despite the platform's wide applicability, some critical and high-value procurements especially those involving specialized equipment for KPIs or donor-funded projects still rely on paper-based documentation or dedicated portals of funding agencies (e.g., World Bank, ADB). This hybrid approach means that Power Grid's procurement operations are not yet fully digitized end-to-end.

Internally, Power Grid uses semi-integrated ERP modules to manage procurement-related data across departments such as procurement, finance, and engineering. These systems facilitate basic tracking of procurement statuses and document approvals but lack full interoperability. As a result, procurement officers often resort to manual follow-ups, spreadsheets, or email communication to coordinate between stages like requisition, approval, delivery, and inspection.

Another limitation is the low level of automation in bid evaluation, supplier performance monitoring, and contract management. Most of these functions are still performed manually, increasing administrative workload and the potential for delays or errors.

In terms of data security and confidentiality, the current systems provide limited safeguards. While access controls and password protection exist, they do not offer the kind of end-to-end encryption, audit trails, or tamper-proof records that are critical for safeguarding procurement of sensitive infrastructure components.

Despite these challenges, Power Grid has demonstrated an openness to embracing new technologies to improve its systems. The successful use of e-GP in many areas reflects institutional readiness for further digital transformation. In this context, blockchain technology presents an opportunity to build upon existing digital platforms, offering greater security, transparency, and efficiency in procurement processes—especially in areas where confidentiality and trust are paramount.

2.6 Regulatory Environment and Policy Landscape

The procurement framework in Bangladesh is shaped by two foundational legal instruments: the Public Procurement Act (PPA) 2006 and the Public Procurement Rules (PPR) 2008, both enacted to ensure transparency, accountability, and value-for-money in public sector procurement. These regulations apply to all government entities, including Power Grid Bangladesh PLC, and mandate structured processes for procurement planning, tendering, evaluation, contract awarding, and post-contract management.

To support these goals, the CPTU under the Ministry of Planning oversees the implementation of procurement rules and the digitalization of processes through the e-GP (Electronic Government Procurement) platform. Power Grid has embraced e-GP for a significant portion of its tendering activities, particularly for routine goods and services. The platform allows for online tender publishing, bid submission, evaluation, and contract notification, thereby reducing paper usage, shortening timelines, and increasing bidder participation.

For donor-financed projects, Power Grid must also comply with procurement guidelines issued by agencies like the World Bank, Asian Development Bank (ADB), and Japan International Cooperation Agency (JICA). These guidelines often demand additional levels of scrutiny, documentation, and auditability, aligning well with international procurement standards.

However, despite this structured environment, Bangladesh currently lacks a regulatory framework specifically addressing emerging technologies such as blockchain. There is no legal recognition of smart contracts, distributed ledgers, or digital tokens in public procurement procedures. This regulatory gap creates uncertainty in areas such as:

- The legal enforceability of blockchain-based contracts
- The role of digital signatures and timestamps within blockchain ecosystems
- Responsibility and accountability in decentralized systems
- Data privacy and compliance with the Digital Security Act

Additionally, government policies and procurement rules do not currently permit or mention decentralized, tamper-proof ledgers for use in public tenders or contract administration. This lack of policy alignment limits the ability of entities like Power Grid to experiment with or implement blockchain-based procurement models, even on a pilot basis.

To enable future adoption, there is a pressing need for policy modernization, including pilot-friendly regulatory provisions that define the legal standing of blockchain records, set standards for smart contract design, and establish accountability mechanisms for automated procurement workflows. Without such legal clarity, the application of blockchain in public sector procurement though seems technically feasible, it may still remain institutionally constrained.

Chapter 3

Introduction

3.1 Background of the Research

Blockchain technology is emerging as a transformative force across industries, offering unprecedented levels of transparency, security, and efficiency in operations. Modern companies are increasingly adopting blockchain due to its ability to enhance trust among stakeholders, automate processes through smart contracts, and provide immutable records of transactions [1][2]. These features make blockchain particularly relevant for critical sectors such as power transmission utilities, which invest billions in equipment procurement annually. For instance, the global electricity transmission and distribution market—including procurement and associated services—is estimated to reach trillions of dollars in value, underscoring the scale and importance of efficient procurement practices in this domain [1]. Countries that adopt blockchain for power transmission utilities will likely gain a competitive edge by ensuring the confidentiality of sensitive information like equipment model name and identification numbers, reducing cyber-threats, reducing procurement inefficiencies, mitigating risks, enhancing transparency and fostering greater trust among stakeholders.

3.2 Problem Statement

Power transmission utilities face unique challenges, including ensuring the confidentiality of sensitive information and mitigating risks related to cyber-security and procurement inefficiencies. The 2010 Stuxnet cyber-attack on Iran's nuclear power plant serves as a stark reminder of how vulnerabilities in procurement processes can have catastrophic consequences. In the case of Stuxnet, hackers exploited detailed knowledge of specific equipment models and their vulnerabilities to target critical infrastructure [3]. Such incidents highlight the urgent need for robust systems to secure procurement data and equipment specifications. Blockchain, with its decentralized and immutable ledger, can be instrumental in addressing these risks by providing a secure, tamper-proof platform for managing procurement data. Blockchain technology has the potential to revolutionize the procurement and supply chain management (SCM) processes of power transmission utilities. By leveraging blockchain's inherent characteristics—transparency, immutability, and

decentralized trust—utilities can streamline procurement, reduce costs, and enhance operational efficiency. For instance, the use of smart contracts can automate the procurement lifecycle, from vendor selection to payment processing, significantly reducing delays and errors. Similar benefits have been reported in pilot implementations across the public and energy sectors, where smart contracts improved procurement efficiency, compliance, and auditability [4]. Furthermore, blockchain's transparency ensures that all transactions are visible to authorized parties, reducing opportunities for corruption and ensuring accountability across the supply chain. Another critical advantage of blockchain is its ability to enhance the security of sensitive information. In the context of power transmission utilities, procurement often involves acquiring specialized equipment for KPIs, where confidentiality is paramount. Blockchain's cryptographic security mechanisms ensure that equipment specifications and procurement details remain accessible only to authorized entities. This reduces the risk of data breaches and potential cyberattacks, such as those witnessed in the Stuxnet case [3]. Additionally, blockchain can be integrated with IoT (Internet of Things) devices to monitor and verify equipment quality and compliance, further strengthening the integrity of procurement processes [2]. The introduction of blockchain into power transmission utilities also aligns with the broader trends of digital transformation in the energy sector. As utilities face growing pressure to optimize costs and improve service reliability, blockchain offers a compelling solution for modernizing their procurement and supply chain processes [1].

3.3 Objectives of the Study

The objectives of this research are:

a) **Assess the Potential of Blockchain in Procurement and SCM for Power Transmission**:
   - Explore how blockchain can enhance transparency, efficiency, and security in procurement and supply chain management processes within power transmission utilities.

b) **Evaluate the Current State and Readiness in Bangladesh**:
   - Analyze the current state of power transmission utilities in Bangladesh.
   - Assess the readiness and challenges faced by these utilities in adopting blockchain technology for procurement and SCM.

c) **Identify Implementation Challenges**:
    - Explore technical, organizational, and regulatory challenges specific to implementing blockchain in the procurement and supply chain management of the power transmission sector in Bangladesh.
    - Examine potential solutions and strategies to overcome these challenges.

d) **Develop a Roadmap for Implementation**:
    - Propose a practical implementation framework for blockchain technology tailored to the needs and context of power transmission utilities in Bangladesh.
    - Provide recommendations for policymakers, utility companies, and other stakeholders to facilitate the adoption of blockchain in procurement and SCM.

3.4 Research Questions

The study will focus on getting clarification on the following research questions:

a) What are the specific benefits of blockchain technology for procurement and supply chain management in power transmission utilities?
b) What is the current state of blockchain adoption in the energy sector globally, and what lessons can Bangladesh learn from these cases?
c) What are the technical, regulatory, and organizational challenges of implementing blockchain in the procurement and supply chain management of the power transmission sector in Bangladesh?
d) How can these challenges be addressed to ensure successful implementation?

3.5 Scope and Significance of the Study

The scope of this study is limited to the implementation of blockchain technology in the procurement and supply chain management of power transmission utilities in Bangladesh. It explores the current state, readiness, and challenges faced by these utilities, while drawing comparative insights from global best practices. The significance of this study lies in its potential to inform policymakers, utility managers, and technology developers on how blockchain can revolutionize procurement practices in a high-investment, high-risk sector. With billions spent annually on transmission infrastructure, improving efficiency,

transparency, and security in procurement can have far-reaching impacts on economic and operational performance.

3.6 Limitations of the Study

Despite its exploratory nature, this study faces several limitations:

- **Limited empirical data:** Given the nascent stage of blockchain adoption in Bangladesh's power sector, access to real-world implementation data may be restricted.
- **Technological complexity:** Understanding the nuances of blockchain technology may require technical depth that could limit the accessibility of the research for non-expert stakeholders.
- **Stakeholder availability:** Reaching a broad spectrum of stakeholders for primary data collection may affect the comprehensiveness of survey responses.

These limitations will be addressed by triangulating data sources and focusing on verified case studies and expert opinions.

Chapter 4

Literature Review

4.1 Introduction

Procurement and supply chain processes, particularly in large-scale public and infrastructure sectors, are often burdened by inefficiencies, fraud risks, and limited transparency. As globalization and digital transformation reshape traditional business models, there is a growing need to modernize procurement frameworks through technologies that enhance traceability, security, and operational speed. Among the emerging technologies, blockchain has gained significant attention due to its ability to provide decentralized, immutable, and transparent records of transactions. In such decentralized systems, each transaction is verified by a consensus of the majority of participants, and once recorded, the information becomes permanent and cannot be altered or erased [5].

The relevance of blockchain in procurement has become particularly prominent in sectors that deal with high-value, sensitive, or confidential acquisitions, such as defense, aviation, and energy. In these domains, breaches in procurement confidentiality or manipulation of procurement records can have serious consequences, ranging from financial losses to strategic vulnerabilities. The power and energy sector, in particular, has seen rising interest in blockchain-enabled procurement systems due to the critical nature of the infrastructure and the increasing threat of cyber-attacks targeting operational technology (OT) and KPIs**.**

The importance of secure procurement is further underscored by incidents like the Stuxnet malware attack, which exploited detailed knowledge of industrial equipment used in a nuclear facility [3]. This example illustrates how exposure of procurement details, even during routine bidding processes, can be leveraged for cyber sabotage. As a result, power utilities worldwide are increasingly exploring blockchain as a means of maintaining confidentiality and integrity across procurement stages ranging from tendering and contract approval to delivery tracking and audit compliance.

Blockchain’s potential lies in its core attributes: immutability, cryptographic security, distributed consensus, and smart contract automation. These features collectively enable secure handling of procurement data, automated verification of supplier credentials, real-time

visibility across supply chains, and tamper-proof documentation. The benefits of blockchain in procurement have already been demonstrated across a range of industries.

Hitachi, for instance, adopted blockchain-backed, Electronic Signature Service (ESS) to digitize its internal contract and procurement processes. By replacing paper-based approvals with a blockchain-powered digital signature system, Hitachi ensured tamper-proof documentation and immutable records, reducing the processing time for over 400 contract cases per month by nearly 20% while enhancing auditability and data security [6].

In the automotive sector, Tech Mahindra piloted a blockchain-enabled "procure-to-pay" network for a large U.S.-based original equipment manufacturer (OEM). This system connected all procurement stakeholders such as suppliers, logistics providers, customs officials, and finance teams within a decentralized ledger. The result was a 40% reduction in transaction time, improved document integrity, and real-time visibility across the entire supply chain [7].

The IBM–Maersk TradeLens platform, although rooted in global shipping and logistics, offers strong parallels to procurement. The system used blockchain to manage documents such as bills of lading, contracts, and customs clearances achieving 15% cost savings and 30% faster document cycles, while eliminating the risk of forged or altered records [8]. These improvements directly address procurement pain points like contract fraud, delays, and manual reconciliation.

In the energy domain, SP Group in Singapore developed a blockchain-based Renewable Energy Certificate (REC) platform to enable secure, traceable procurement and validation of clean energy. By ensuring end-to-end transparency and confidentiality in asset certification, SP Group reinforced trust among buyers and regulators, particularly in high-value or regulated transactions [9].

Though these organizations operate in diverse sectors, their blockchain applications reflect a shared goal: securing sensitive procurement processes through decentralized, tamper-proof platforms that streamline operations, mitigate fraud, and establish traceable audit trails. Notably, while the use of blockchain to procure classified or confidential equipment is still emerging, the underlying technologies such as permissioned ledgers**,** encrypted data layers**,** and smart contracts are already being used to protect sensitive transaction data.

4.2 Sources of Information

The foundation of this study is built upon a wide range of scholarly publications, industry reports, and institutional documents that highlight the growing relevance of blockchain technology in procurement and supply chain management. These sources not only provided a theoretical framework but also illustrated practical use cases and sector-specific insights that shaped the research problem, objectives, and methodology.

A major inspiration for this study was the work by Andoni et al. [2], which offered a comprehensive review of blockchain applications in the energy sector. The paper identified key operational areas including asset management, billing systems, and energy trading where blockchain significantly enhances transparency and trust. This helped frame the potential of blockchain beyond conventional financial transactions and positioned it as a strategic enabler in power sector operations.

Another influential reference was the paper by Francisco and Swanson [10], which explored the use of blockchain to improve transparency in supply chains. The authors argued that decentralized ledger systems can create a tamper-proof history of procurement activities, thus reducing corruption, delays, and documentation fraud. These findings directly aligned with the research objective of enhancing transparency and auditability in procurement processes for state-owned utilities like Power Grid Bangladesh PLC.

The World Economic Forum's guidance on blockchain deployment offers practical insights for public sector organizations aiming to adopt the technology [11]. It highlights the need for stakeholder coordination, clear regulatory frameworks, and phased implementation which are the factors that are particularly relevant in the context of Bangladesh's public procurement environment. The IBM (Institute for Business Value) has also published multiple reports emphasizing the benefits of blockchain in procurement, including automation of workflows, improved supplier verification, and reduced compliance risks [12]. These insights underscored blockchain's potential to modernize procurement frameworks in capital-intensive sectors.

In the local context, government policies and procurement frameworks issued by CPTU Bangladesh**,** BERC**,** and the Ministry of Power, Energy and Mineral Resources were reviewed to understand the structural and regulatory conditions under which blockchain

could be implemented. While these sources do not directly reference blockchain, they helped identify areas of vulnerability such as lack of end-to-end digital integration and information security that blockchain can potentially address.

Furthermore, articles on the Stuxnet cyber-attack and its implications for operational technology security [3] reinforced the urgency of securing procurement information, particularly for critical infrastructure KPIs. The attack illustrated how procurement records, if intercepted or manipulated, could become vectors for cyber sabotage—thus making the case for encrypted, decentralized procurement platforms even stronger.

Additional insights were obtained from applied case studies such as Hitachi's blockchain-powered contract management system [6], Tech Mahindra's procure-to-pay pilot [7], the IBM–Maersk TradeLens platform [8], and SP Group's renewable energy certificate platform [9]. These real-world implementations demonstrated measurable gains in efficiency, security, and transparency—all of which are directly relevant to the objectives of this thesis.

4.3 Gap Analysis in Current Practices

The integration of blockchain technology in procurement demands both organizational and technical preparedness, as well as a strategic understanding of the existing limitations within current systems. In the case of Power Grid Bangladesh PLC, several foundational gaps exist that need to be addressed before meaningful adoption can occur.

On the organizational front, Power Grid has made visible progress toward digital transformation, particularly through the implementation of the e-Government Procurement (e-GP) platform and the partial integration of Enterprise Resource Planning (ERP) tools. Senior leadership has demonstrated interest in increasing transparency, efficiency, and security in procurement operations. However, a deeper analysis reveals that awareness of blockchain technology remains limited, especially among mid-level officials and operational staff. Concepts such as distributed ledgers, peer-to-peer verification, and smart contracts are not widely understood, leading to potential resistance or uncertainty when new technologies are introduced.

The absence of formal training programs or institutional guidelines around blockchain further complicates adoption. For blockchain to be effectively implemented, organizational

restructuring would be required in several areas, including capacity-building for procurement and IT personnel, internal policy revision to accommodate decentralized data handling, and cross-functional coordination between engineering, finance, legal, and audit departments.

From a technical perspective, Power Grid operates with legacy IT systems designed for centralized control and basic automation. These systems do not support integration with decentralized blockchain networks, nor do they offer features such as cryptographic verification, permissioned access, or real-time audit trails features that are central to blockchain's value proposition. Existing digital tools also lack the interoperability, application programming interfaces (APIs), and smart contract infrastructure required for a blockchain ecosystem.

Cyber-security practices, while present, are largely limited to traditional measures such as firewalls, antivirus protection, and password-controlled access. Blockchain deployment would necessitate a more sophisticated digital security framework, incorporating public-private key encryption, digital signatures, and layered access control. In addition, there is currently limited collaboration between the procurement and IT departments—an institutional gap that could pose a serious barrier to implementing a cross-functional technology like blockchain.

Beyond the internal environment, broader sectoral challenges persist in Bangladesh’s power transmission procurement landscape. Although public tendering has been digitized to some extent, procurement platforms are still limited in functionality. Features such as real-time data sharing, verifiable tracking of procurement stages, and tamper-evident audit logs are largely absent. This leads to inefficiencies, delays, and limited accountability, particularly in managing high-value or sensitive equipment.

Confidentiality is another critical concern. Power transmission utilities often procure strategic components such as SCADA systems, protective relays, software-based control devices, and cyber-physical infrastructure. Inadequate control over procurement data increases the risk of cyber threats, especially if specification details are accessed by unauthorized individuals. The presence of multiple intermediaries and departments further complicates secure data management, with varying access rights and inconsistent enforcement of confidentiality protocols.

In addition to organizational and technical gaps, contextual factors such as national energy availability must also be considered. As a developing country with ongoing challenges in meeting electricity demand, Bangladesh may face practical limitations in adopting technologies that consume high levels of computational power. Zheng et al. (2018) highlight that certain blockchain consensus mechanisms, particularly Proof of Work (PoW), are energy-intensive and may not be suitable in contexts where energy resources are constrained [13]. While more efficient consensus models exist, the overall energy footprint of blockchain implementation could still be a barrier in settings where electricity reliability and affordability remain critical concerns. Therefore, energy considerations should be integrated into the technology selection and design phase when planning blockchain adoption in public sector utilities like Power Grid.

Despite these challenges, there are notable opportunities. Blockchain's decentralized and tamper-resistant architecture provides a strong foundation for redesigning procurement systems. Smart contracts could automate complex procedures such as bid evaluations, vendor compliance checks, and payment approvals reducing human error and improving processing time. Permissioned blockchain networks also offer enhanced confidentiality by allowing access only to verified participants, ensuring sensitive data remains protected.

The centralized nature of Bangladesh's power transmission sector could also be an advantage. A unified approach to blockchain implementation would enable the standardization of procurement procedures, consistent data handling protocols, and coordinated vendor management. Such reforms would not only increase operational efficiency but also strengthen trust among stakeholders, including regulatory bodies, development partners, and international vendors.

Chapter 5
Blockchain Technology Concepts and Applications

5.1 Overview of Blockchain Technology

Blockchain is a decentralized, distributed ledger technology that allows for the secure recording and sharing of data across a network of computers, eliminating the need for intermediaries and enhancing trust among users. Originally conceptualized as the underlying technology for Bitcoin by Satoshi Nakamoto in 2008, blockchain has since evolved to support various applications across industries [14]. Each block in the blockchain contains a timestamp, transaction data, and a cryptographic hash of the previous block, ensuring immutability and resistance to data tampering.

Blockchain is built on the principles of decentralization, transparency, and cryptographic security. This ensures that no single entity controls the entire chain, which significantly reduces the risk of centralized failure and corruption. Blockchain technology operates using consensus mechanisms such as Proof of Work (PoW), Proof of Stake (PoS), ensuring that transactions are validated in a secure and decentralized manner.

PricewaterhouseCoopers (PwC) defines the blockchain technology as follows: "*Blockchain is a technology that allows data to be stored and exchanged on a peer-to-peer (P2P) basis. Structurally, blockchain data can be consulted, shared and secured thanks to consensus-based algorithms. It is used in a decentralized manner and removes the need for intermediaries, or "trusted third parties"* [15].

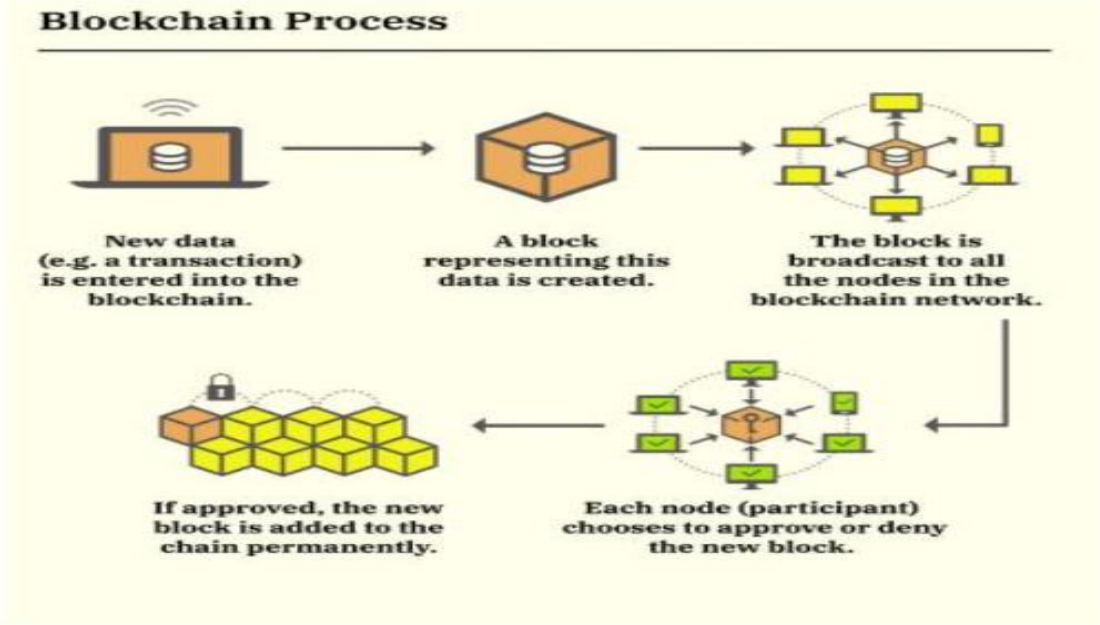

Figure 3: Blockchain Process

5.2 Key Features of Blockchain

Blockchain technology's revolutionary impact stems from five fundamental features that distinguish it from traditional database systems and centralized networks. These characteristics work synergistically to create a robust, secure, and efficient platform for digital transactions and data management across various applications.

Decentralization

Unlike conventional networks where a single person or organization oversees the entire process, blockchain facilitates a truly decentralized approach2. This fundamental characteristic means there is no single point of authority, and the system positions every user equally in a position of control and responsibility. Decentralization provides numerous benefits, with security being paramount among them. Since the system distributes itself throughout the network, a single point of failure cannot affect the entire system's functionality. Moreover, this distributed architecture provides enhanced protection against hackers and malicious attacks, as compromising one node does not grant access to the entire network.

Immutability

One of the most critical features of blockchain technology is its immutable nature2. Data cannot be modified or changed once recorded in a blockchain, thus creating a permanent and unalterable chain of events. This immutability provides exceptional stability, allowing users to store their assets and information without worrying about any third-party intervention or unauthorized modifications. The immutable nature of blockchain is made possible through the implementation of cryptographic hash functions and the distributed network of nodes that maintain consensus about the blockchain's state.

Consensus and Unanimity

In a blockchain network, no single participant can add a block without proper consent from the network. Before adding any data, all participating users must agree that the information entered is genuine and valid through established consensus mechanisms. This ensures that every piece of data is added to the network simultaneously and that updates are propagated quickly throughout the system. In most cases, before entering a blockchain, all users must agree on the shared state of the blockchain, preventing fraudulent or erroneous transactions from being recorded.

Enhanced Security

Blockchain ensures that all individual data remains secure through multiple layers of protection. This security is achieved through end-to-end encryption protocols that protect data transmission and storage. Additionally, every piece of data has its own unique cryptographic identity on the network, making it virtually impossible to forge or duplicate. Therefore, blockchain technology facilitates both security and privacy, making it a groundbreaking solution for sensitive data management and secure transactions.

Faster Settlement

Blockchain significantly reduces settlement times by removing intermediaries from transactional processes. Traditional financial transactions often require multiple intermediaries, each adding time and cost to the process. Blockchain's direct peer-to-peer architecture enables faster settlements while system automation reduces human error. Both features combine to reduce settlement time significantly and make transactions much more

efficient, particularly beneficial for international transfers and complex multi-party agreements.

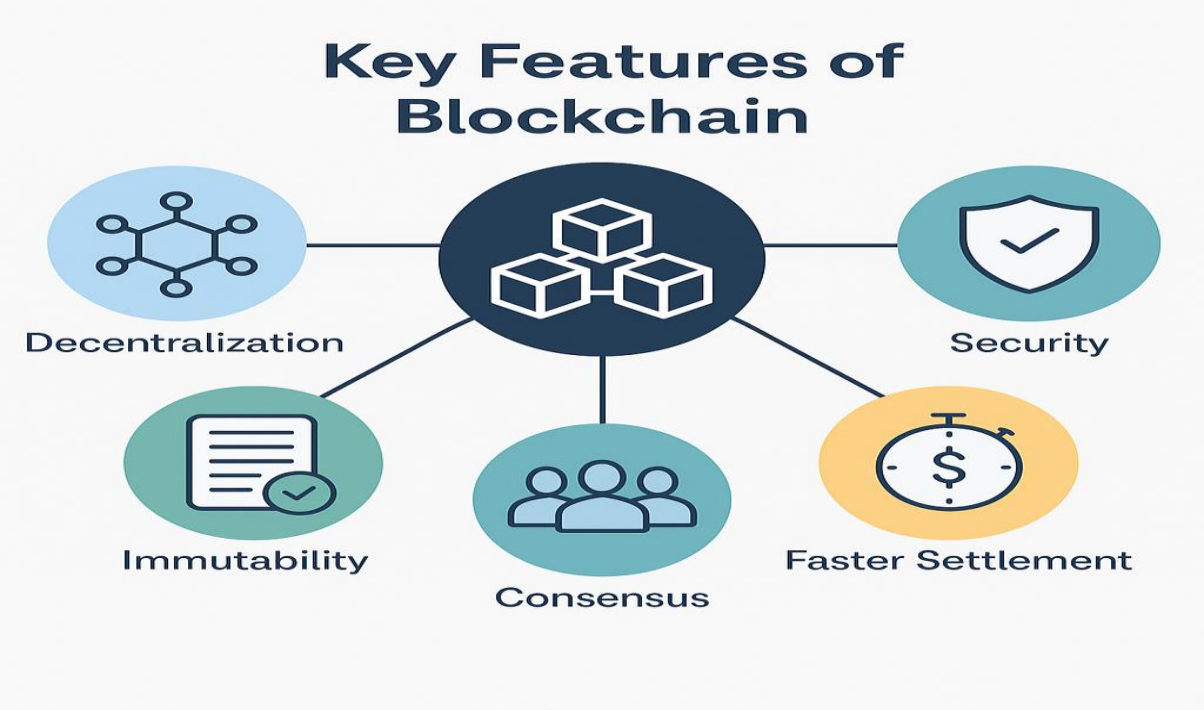

Figure 4: Key Features of Blockchain

5.3 Types of Blockchain

The blockchain ecosystem encompasses four distinct types, each designed to serve specific use cases and organizational requirements. These variations differ primarily in their access controls, governance structures, and the level of decentralization they implement.

Public Blockchain

A public blockchain represents a non-restrictive, permission-less distributed ledger system that operates without central authority or access limitations. Any node or user participating in a public blockchain is authorized to access current and historical records, verify transactions, perform proof-of-work for incoming blocks, and engage in mining activities. Public blockchains exemplify true decentralization, as they allow global participation without requiring approval from any central entity. Bitcoin and Ethereum serve as prime examples of public blockchains, where anyone with internet access can participate in the network, submit transactions, and contribute to the consensus process.

Private Blockchain

In contrast, a private blockchain operates as a restrictive or permissioned system that functions only within a closed network environment. Private blockchains are typically utilized within organizations or enterprises where only selected members are permitted to participate in the blockchain network. The controlling organization maintains complete authority over security levels, authorizations, permissions, and accessibility. While private blockchains share functional similarities with public blockchains, they operate within small and restrictive networks, providing enhanced control and privacy for sensitive business operations.

Consortium Blockchain

Consortium blockchains represent a semi-decentralized approach where multiple organizations collaboratively manage a blockchain network. In this model, more than one organization can act as a node, enabling controlled information exchange and mining activities among trusted partners. This type provides a middle ground between the openness of public blockchains and the restrictive nature of private ones, making it particularly suitable for industry collaborations, regulatory compliance scenarios, and Business-to-Business (B2B) applications where multiple parties need shared access to certain information.

Hybrid Blockchain

Hybrid blockchains combine elements of both private and public blockchain architectures. This innovative approach utilizes features from both types, allowing organizations to maintain a private permission-based system alongside a public permission-less system. With hybrid networks, users can precisely control who gains access to specific data stored in the blockchain. Only selected sections of data or records can be made publicly accessible while keeping the remainder confidential within the private network. The hybrid system offers flexibility, enabling users to easily connect private blockchains with multiple public blockchains. Transactions within the private network of a hybrid blockchain are typically verified within that network, maintaining security and privacy while enabling selective transparency.

5.4 Applications of Blockchain

Blockchain technology has emerged as a foundational innovation with wide-ranging applications across multiple sectors. Its decentralized and secure nature allows for the creation of tamper-proof digital records, enabling trustless interactions between parties. This section discusses the key applications of blockchain in various industries, showcasing its transformative potential.

1. Financial Services

The financial sector was among the first to adopt blockchain due to its ability to eliminate intermediaries and reduce transaction costs. Blockchain supports peer-to-peer (P2P) transfers, cross-border payments, smart contracts, and decentralized finance (DeFi) platforms. It also enables real-time settlement of trades and enhances transparency and auditability in financial transactions.

2. Supply Chain Management (SCM)

Blockchain ensures transparency, traceability, and accountability across the supply chain. It enables stakeholders to verify the authenticity and origin of goods, track shipment progress, and validate certifications. From raw material sourcing to end-user delivery, blockchain helps reduce fraud, improve logistics coordination, and enhance consumer trust [10].

3. Healthcare

In healthcare, blockchain is used for secure patient data management, interoperable electronic health records (EHRs), and drug traceability. It ensures the integrity of medical data and helps prevent counterfeit drugs by tracing the pharmaceutical supply chain.

4. Energy Sector

Blockchain applications in the energy industry include peer-to-peer (P2P) energy trading, renewable energy certificate (REC) tracking, and decentralized grid management. Smart contracts enable automated billing and usage settlement in microgrids, improving efficiency and reducing operational costs.

5. Public Sector and Governance

Governments are exploring blockchain for land registry, digital identity, voting systems, and public procurement. By providing tamper-proof records and immutable audit trails, blockchain can reduce corruption, enhance transparency, and foster public trust.

5.5 Applications of Blockchain in Procurement and SCM

Procurement and supply chain management are vital for sectors like power transmission, where equipment is expensive, specialized, and often sourced from multiple suppliers. Traditional procurement systems suffer from delays, lack of transparency, and data silos. Blockchain addresses these challenges by offering a secure, decentralized, and tamper-proof ledger.

Transparency and Traceability

Blockchain provides end-to-end visibility in procurement processes. Each transaction—such as purchase orders, shipments, and inspections—is recorded and time-stamped on a shared ledger accessible to all stakeholders. This traceability is crucial for verifying the authenticity and quality of equipment, helping avoid counterfeit parts.

Smart Contracts

Smart contracts automate procurement tasks such as vendor selection, payment processing, and compliance verification. Once a condition is met—like delivery confirmation—a smart contract can trigger the next step, reducing delays and improving trust between buyers and suppliers.

Data Security

Procurement involves sensitive information. Blockchain uses cryptographic security to protect data, ensuring that once recorded, it cannot be changed without consensus. This makes the process more secure against fraud, tampering, or unauthorized access.

B2B Collaboration

Blockchain enables seamless B2B integration by connecting ERP systems and stakeholders in real time. It improves coordination among vendors, logistics providers, and utilities, leading to faster decision-making and fewer disputes.

Industry Adoption

Several global energy firms and utilities have started using blockchain to streamline procurement. These pilots show improved transparency, reduced paperwork, and cost savings—making a strong case for broader adoption in power transmission utilities.

5.6 Relevance of Blockchain for Power Transmission Utilities

Power transmission utilities operate in an environment that demands high levels of efficiency, reliability, and security. These organizations are responsible for managing extensive procurement cycles involving large volumes of high-value, technically sensitive equipment such as transformers, switchgears, insulators, and protection systems. Ensuring timely and secure procurement of these assets is not just a matter of operational excellence but of national interest, particularly in developing countries where power infrastructure is rapidly expanding. In this context, blockchain technology holds significant promise.

One of the main reasons blockchain is highly relevant for power transmission utilities is data integrity and cybersecurity. In the wake of cyber incidents like the Stuxnet attack on Iran's nuclear facility, where attackers exploited knowledge of a specific Siemens PLC model to infiltrate the system, the importance of safeguarding procurement information has become critical. Blockchain's immutable ledger makes it extremely difficult for unauthorized parties to alter procurement records, equipment specifications, or tendering data, thereby reducing the risk of targeted cyberattacks.

Another key benefit lies in supply chain visibility and traceability. With a decentralized blockchain system, all stakeholders including vendors, inspectors, warehouse managers, and engineers can access a single, synchronized version of transaction history. This is particularly valuable in power transmission where procurement involves multiple actors and long lead times. Blockchain ensures that every step, from purchase order generation to equipment delivery and testing, is recorded and verifiable in real-time. This level of visibility minimizes fraud, ensures compliance with standards, and supports better decision-making.

Blockchain also facilitates efficient contract execution through smart contracts. For power transmission utilities managing multiple concurrent infrastructure projects, automating contract clauses such as payment triggers, inspection approvals, or warranty activations can save considerable time and administrative resources. For example, once a certified third party verifies that a transformer meets quality standards and has been delivered to site, the system

can automatically release payment without waiting for manual approval chains. This streamlines the entire process and enhances project execution speed.

Furthermore, the technology enhances auditability and regulatory compliance. Power utilities are often subject to rigorous audits by governmental and international agencies. Blockchain's transparent and tamper-proof recordkeeping can drastically reduce the complexity and cost of such audits, offering easily accessible logs of all procurement-related transactions. This is especially useful in donor-funded or PPP-based (public-private partnership) projects where financial and procedural transparency is a prerequisite.

Lastly, the relevance of blockchain extends to future-proofing the transmission network. As the energy sector moves toward smart grids and interconnected systems driven by data, the underlying infrastructure must be built on secure and interoperable platforms. Blockchain, by offering decentralized consensus, encrypted communication, and real-time validation, aligns with this long-term vision of digital, secure, and autonomous infrastructure management.

Chapter 6
Research Methodology

6.1 Research Philosophy and Approach

The study is grounded in the interpretivist research philosophy, which emphasizes the importance of understanding social realities from the perspectives of the individuals involved. Interpretivism is particularly appropriate when studying emerging technologies within a specific organizational and institutional context, where the understanding, adoption, and impact of the technology can vary among stakeholders. This philosophical stance supports the exploration of perceptions, behaviors, and experiences of procurement professionals, IT experts, and policy actors regarding blockchain implementation.

In line with interpretivism, the study adopted an inductive research approach, allowing theory and understanding to emerge from the data rather than testing pre-existing hypotheses. Given the limited research on blockchain in the context of Bangladesh's power sector, this approach was suitable for identifying patterns, relationships, and variables that may not have been previously considered [16]. The goal was to build a foundation of knowledge that could inform both academic inquiry and practical implementation strategies.

6.2 Research Design

A qualitative-dominant exploratory research design was employed to capture the nuances of blockchain's potential application in procurement processes. Exploratory research is particularly useful for investigating under-researched topics or addressing ambiguous problems that require further clarification [16]. The study sought to explore the readiness, perceptions, benefits, and risks associated with blockchain implementation through a combination of descriptive data and thematic insights.

While the study incorporated both qualitative and quantitative elements, the primary emphasis was placed on exploratory analysis. This allowed for flexibility in data interpretation and facilitated a better understanding of the key challenges and strategic considerations specific to Power Grid and similar public utilities. The design also enabled

triangulation of primary and secondary data, thereby increasing the credibility and validity of findings.

6.3 Research Objectives

The methodological framework was structured around the research objectives outlined earlier in the thesis. These objectives included: assessing the potential of blockchain to enhance transparency, security, and efficiency in procurement; evaluating the current level of digital maturity and institutional readiness in Bangladesh's power sector; identifying technical, organizational, and regulatory challenges; and developing a strategic roadmap for blockchain integration tailored to the needs of Power Grid Bangladesh PLC.

The methodology was selected to generate insights capable of directly informing these objectives and supporting the development of actionable recommendations for policymakers, practitioners, and other stakeholders in the energy sector.

6.4 Population and Sampling

The target population consisted of professionals involved in procurement, contract management, supply chain operations, information technology, and regulatory compliance within the Bangladeshi power transmission ecosystem. This included personnel from Power Grid Bangladesh PLC, as well as employees from associated public utilities and relevant private sector organizations.

A purposive sampling technique was adopted to ensure the selection of participants with relevant domain expertise and experience. Unlike random sampling, purposive sampling is particularly useful in exploratory research as it allows for the intentional selection of individuals who are most likely to provide meaningful insights on the research topic [16]. A total of 30 valid responses were collected, with respondents holding diverse roles such as procurement officers, engineers, IT managers, and policy analysts.

The sample was sufficiently diverse to provide a broad understanding of the institutional, operational, and technological factors influencing blockchain adoption in public procurement.

6.5 Data Collection Methods

The study utilized both primary and secondary data collection methods to ensure a holistic understanding of the research problem. Primary data was collected through a structured online questionnaire administered via Google Forms. This allowed for wide geographical reach and efficient collection of standardized data from targeted respondents. The questionnaire design enabled the researcher to assess participants' knowledge of blockchain, perceptions of its benefits and challenges, and their organizational readiness for adoption.

In addition, secondary data was obtained from academic literature, international case studies, government reports, procurement guidelines from donor agencies (e.g., ADB, World Bank), and policy documents relevant to digital transformation in the power sector. These sources provided contextual background and supported the analysis of institutional practices and technological readiness within Bangladesh’s public procurement landscape.

6.6 Instrument Design and Validation

The survey instrument used in this study was developed based on the contextual understanding of the existing procurement system at Power Grid Bangladesh PLC and the theoretical foundations of blockchain technology. The questionnaire was constructed to align with the core objectives of the study focusing on awareness, perceived benefits, organizational readiness, and potential challenges related to blockchain adoption in procurement.

The design of the instrument was informed by the researcher’s professional experience in the sector and supported by a thorough review of relevant academic literature and international case studies on blockchain applications in procurement and supply chain management. The questions were structured to ensure clarity, relevance, and logical flow, incorporating a combination of multiple-choice, Likert-scale, and closed-ended formats to enable both quantitative and qualitative insights.

6.7 Data Analysis

The data collected from the survey was analyzed using descriptive statistical techniques, focusing on frequency distributions, percentages, and visual representation through graphs and charts. The analysis provided insights into how blockchain is perceived by procurement stakeholders, the degree of organizational preparedness, and the specific challenges likely to be encountered in implementation.

Given the exploratory nature of the study, the analysis was non-parametric and interpretive, aimed at identifying trends and relational insights rather than testing hypotheses. Key themes such as “lack of technical expertise,” “regulatory uncertainty,” and “support for pilot initiatives” were identified and interpreted in relation to the broader literature on blockchain and digital procurement transformation.

The analysis also considered contextual factors unique to Bangladesh’s public sector, such as dependence on donor-funded projects, procedural bottlenecks in procurement, and sensitivity around infrastructure confidentiality factors that have significant implications for the design of any future blockchain-based procurement framework.

Chapter 7
Survey Analysis and Findings

7.1 Overview of the Survey Design and Objectives

To assess the awareness, readiness, and perceived impact of blockchain technology on procurement and supply chain management within power transmission utilities, a structured questionnaire survey was conducted. Unlike studies confined to a single entity, this survey targeted employees from multiple public and private sector organizations in Bangladesh. The broader respondent base was chosen to capture a diverse and comprehensive understanding of blockchain's potential role in procurement and supply chain functions within the country's power sector context.

The survey instrument was developed using Google Forms and distributed electronically to professionals engaged in procurement, contract management, supply chain operations, and related fields. The questionnaire comprised both close-ended and multiple-choice questions designed to explore respondents' familiarity with blockchain, perceptions of its benefits and risks, organizational readiness, and opinions on potential implementation areas.

The main objectives of the survey were as follows:

- To evaluate the level of awareness about blockchain technology among procurement and supply chain professionals in Bangladesh.
- To identify perceived benefits of blockchain integration in procurement processes, such as transparency, security, and efficiency.
- To assess the perceived readiness of organizations to adopt blockchain solutions in their operational workflows.
- To identify key challenges and barriers that may hinder blockchain adoption in procurement and supply chain activities.
- To explore which stages of the procurement cycle could benefit most from blockchain implementation.
- To determine the willingness of professionals to support pilot initiatives using blockchain in their respective organizations.

The findings from the survey provide valuable insights into current perceptions, preparedness levels, and anticipated implementation challenges. These insights serve as a basis for further analysis and the formulation of practical recommendations later in this chapter.

7.2 Description of Respondents and Sample Profile

To ensure a well-rounded understanding of perceptions and readiness regarding blockchain adoption, the survey targeted professionals from various public and private organizations engaged in procurement and supply chain activities within Bangladesh. A total of 30 responses were collected, representing a diverse mix of roles, experience levels, and degrees of blockchain familiarity.

Professional Experience:

Respondents were asked to indicate their years of experience in procurement or supply chain roles. As shown in the chart below, the majority of participants had between 1 to 3 years of experience, followed by a notable group with over 7 years. This distribution suggests a balanced perspective across early-career professionals and experienced practitioners.

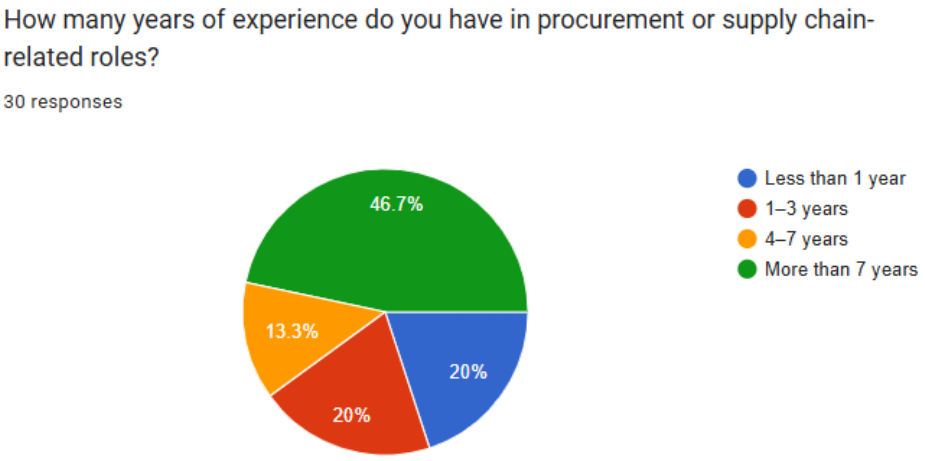

Figure 5: Respondents' Experience in Procurement or Supply Chain Roles

Current Organizational Role:

Respondents also reported their current role or level within their organizations. The sample included professionals at entry-level and trainee positions (20%), mid-level management (56.7%), and a smaller proportion of senior (16.7%) or director-level respondents (6.7%). This mix ensures the inclusion of both operational and strategic viewpoints in the findings.

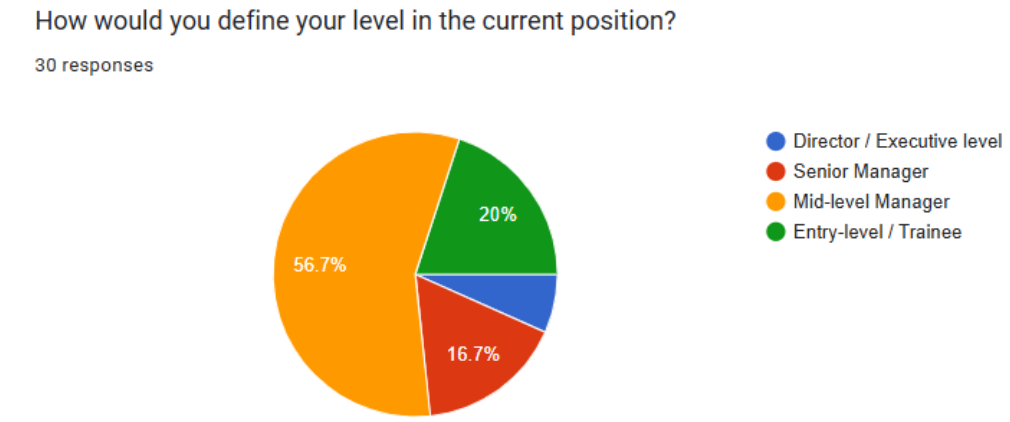

Figure 6: Respondents by Current Role Level

Familiarity with Blockchain:

The survey also assessed respondents' familiarity with blockchain technology. Approximately 37% had heard of blockchain but lacked detailed knowledge, while others indicated varying levels of awareness or understanding. This suggests that although blockchain is known to many, in-depth knowledge remains limited—highlighting a need for awareness and capacity-building if implementation is to be pursued.

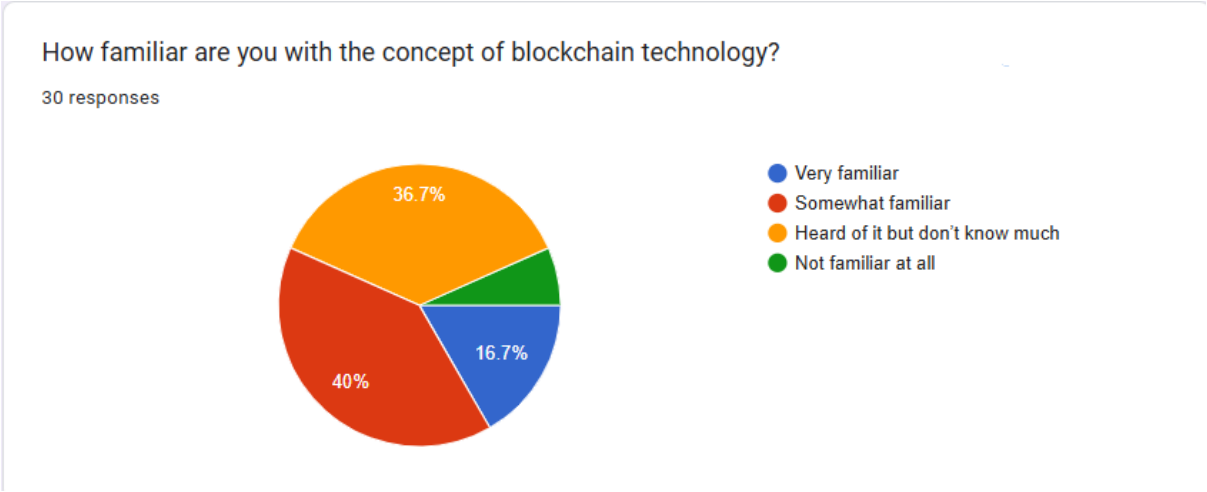

Figure 7: Respondents' Familiarity with Blockchain

This sample profile demonstrates that while blockchain may still be an emerging topic within many organizations, there is a broad interest and engagement with the concept. The diversity of the respondents contributes to a rich data set for understanding the potential benefits and challenges of blockchain implementation, especially in relation to safeguarding sensitive procurement data—an aspect critical in preventing cyber-attacks such as Stuxnet.

7.3 Key Survey Findings

The survey responses reveal several noteworthy trends that reflect the current understanding and outlook toward blockchain adoption in procurement and supply chain operations, particularly within power transmission contexts. The responses also affirm the relevance of blockchain's security-enhancing features, which align with the thesis's broader objective of preventing vulnerabilities such as those exploited in the Stuxnet incident.

Features Associated with Blockchain Technology:

Respondents were asked to select all the features they associate with blockchain. The most commonly chosen features included immutability, secured procurement, and real-time tracking and de-centralization. These selections are aligned with global definitions of blockchain's technical capabilities. Immutability was recognized as a core strength, highlighting blockchain's role in creating tamper-proof records that preserve the integrity of procurement transactions. The emphasis on secured procurement and real-time tracking reflects growing awareness of the need for enhanced system visibility and protection against unauthorized access, especially in the acquisition of critical power infrastructure. Additionally, the selection of decentralization suggests that respondents value the idea of shared control and trust across multiple stakeholders without dependence on a single authority.

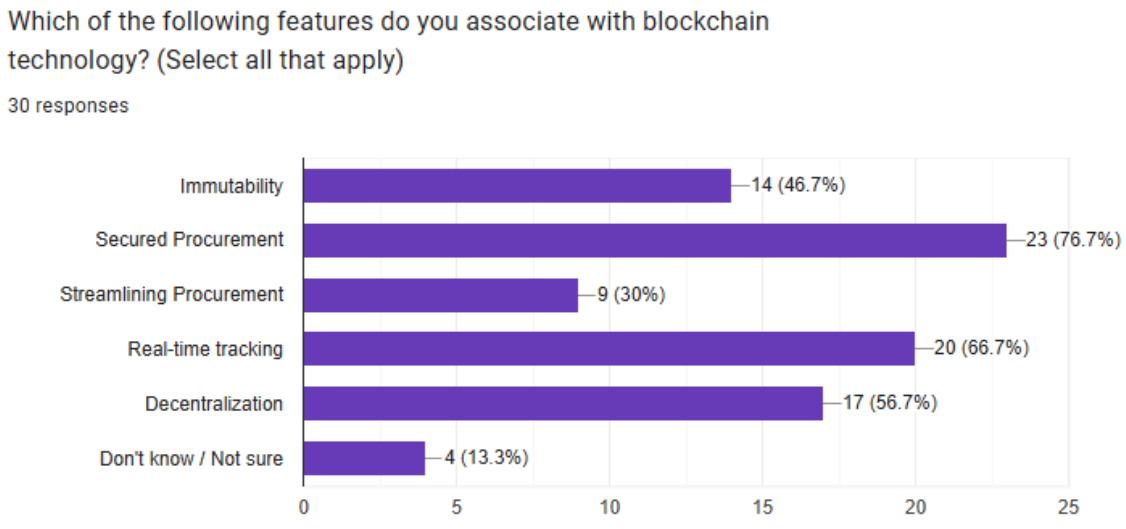

Figure 8: Blockchain Features Identified by Respondents

Agreement on Blockchain's Role in Increasing Transparency:

Respondents were asked whether they believed blockchain could improve transparency in procurement. Out of the total responses, 13 participants strongly agreed with the statement, another 13 participants agreed with the statement, while no one disagreed. This overwhelming agreement reflects a high level of trust in blockchain's potential to create an auditable and tamper-proof procurement record, which is especially important in public sector and donor-funded infrastructure projects. This transparency can reduce scope for manipulation during tendering and contracting processes, thus improving accountability.

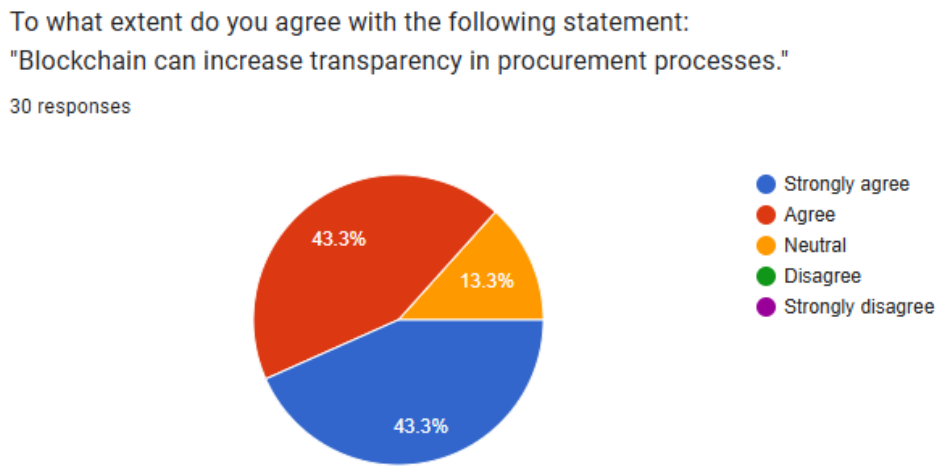

Figure 9: Agreement on Blockchain Improving Transparency

Agreement on Blockchain's Role in Reducing Corruption:

When asked whether blockchain can help reduce corruption in procurement systems, 40% of the respondents strongly agreed, 36.7% of the respondents agreed, while only 3.3% disagreed. This shows a strong belief in blockchain's potential to minimize unethical practices by ensuring that all procurement records are transparent, timestamped, and immutable. The use of decentralized ledgers significantly reduces opportunities for document manipulation or unauthorized changes, thus reinforcing procedural integrity. This is especially relevant in the context of public procurement, where corruption has historically been a major concern in developing countries.

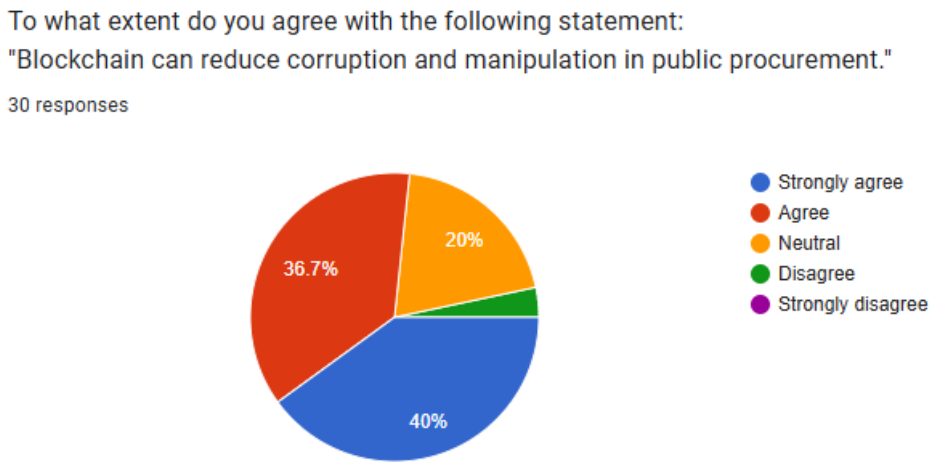

Figure 10: Agreement on Blockchain Reducing Corruption

Agreement on Blockchain's Role in Enhancing Confidentiality:

50% respondents agreed that blockchain can improve the confidentiality of sensitive procurement information, 43.3% respondents think that blockchain may improve the confidentiality and only 6.7% thinks that blockchain can't improve the confidentiality. This is a critical finding, especially for power transmission utilities, where disclosure of technical specifications or equipment identifiers can expose infrastructure to cyber threats. Blockchain's cryptographic architecture and access control mechanisms ensure that only authorized parties can view or alter data, reducing the likelihood of breaches. In light of past cyberattacks—where procurement vulnerabilities were exploited—this strong support reinforces the argument for integrating blockchain to safeguard classified procurement activities.

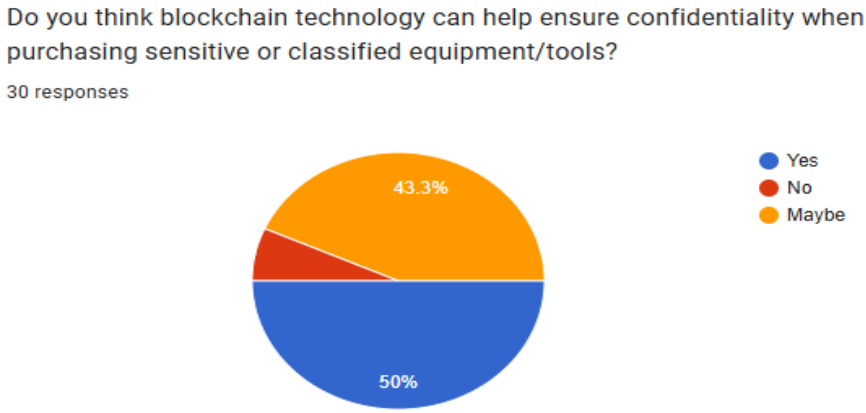

Figure 11: Agreement on Blockchain Enhancing Confidentiality

Beneficial Stages for Blockchain Integration:

Respondents were asked which stages of the procurement process they believed would benefit most from blockchain integration. Notably, all stages of the procurement process were identified as beneficial by respondents, indicating a broad consensus that blockchain can add value across the entire procurement cycle. The stages mentioned include:

- **Tendering:** Highlighted as a key area where blockchain can enhance transparency, ensuring fair competition and reducing opportunities for fraud during the bidding process.
- **Vendor Selection:** Identified as a stage where blockchain can help maintain a transparent and auditable record of the vendor selection process, ensuring that decisions are made based on predefined criteria and are free from manipulation.
- **Contract Management:** Recognized for blockchain's potential to streamline the execution of contracts through smart contracts, improving efficiency and reducing human errors.
- **Delivery and Inspection:** Noted for blockchain's ability to provide real-time tracking of deliveries and automated verification of product quality.
- **Payment Processing:** Identified as a stage where blockchain can speed up transactions, automate payment triggers, and ensure that payments are released only upon fulfillment of contract conditions.

This widespread agreement suggests that blockchain is seen as a comprehensive solution for improving the security, transparency, and efficiency of procurement activities.

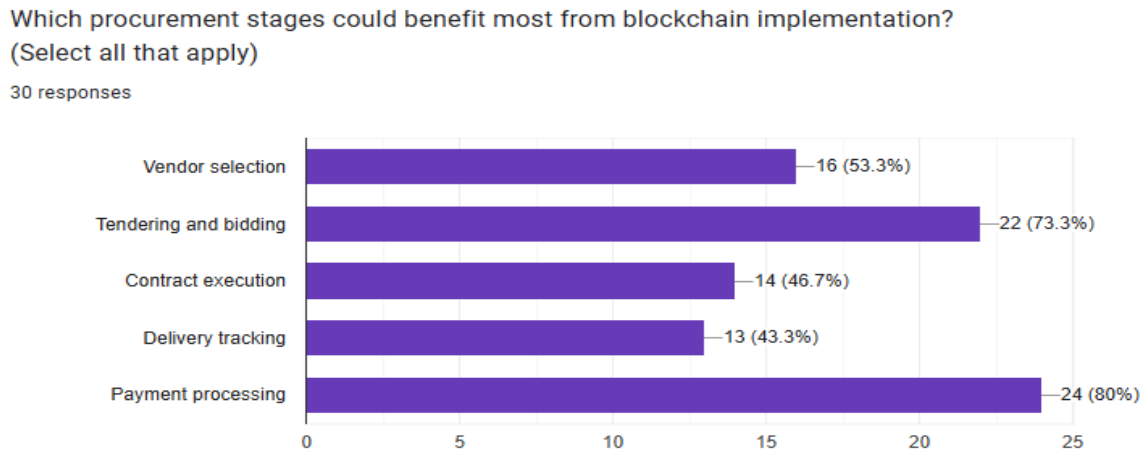

Figure 12: Procurement Stages Identified as Beneficial for Blockchain Integration

Digital Tools Used in Procurement:

Respondents were asked about the digital tools currently employed in their procurement activities. Most of the respondents (66.7%) organization use digital tool in procurement. The most commonly used tools included e-GP, ERP systems, and email for communication and coordination. The high usage of e-GP reflects its widespread adoption in Bangladesh's public procurement processes, while the reliance on ERP systems and email indicates that many organizations are still managing procurement data manually or with semi-integrated solutions. This highlights the potential for further digitalization and integration of blockchain technology to enhance the security, traceability, and efficiency of procurement workflows.

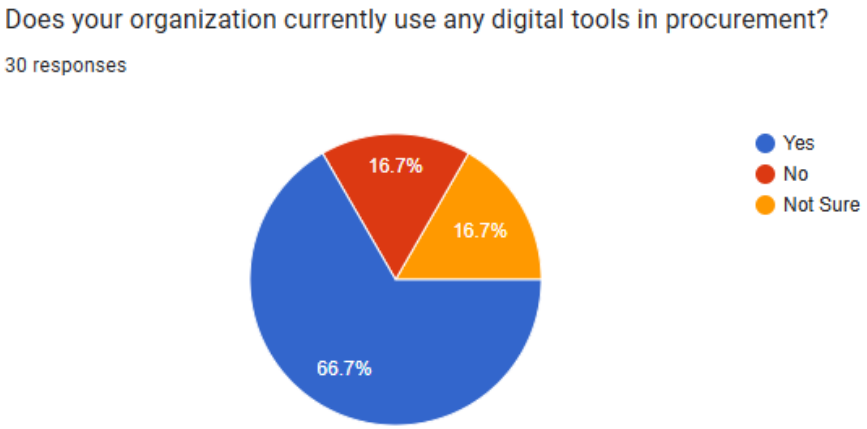

Figure 13: Digital Tools Used in Procurement Processes

Organizational Readiness for Blockchain Adoption:

Respondents were asked to assess their organization's readiness for adopting blockchain technology in procurement. The majority (56.7%) of respondents indicated that their organizations are not ready for blockchain adoption, while 26.7% felt their organizations were somewhat ready. Only 6.7% considered their organization to be fully ready, and 10% were unsure. This suggests that while there is interest in blockchain technology, many organizations face significant barriers to its adoption, such as lack of technical expertise, infrastructure, or internal support. These results highlight the need for a phased approach to implementation, starting with pilot programs and organizational training.

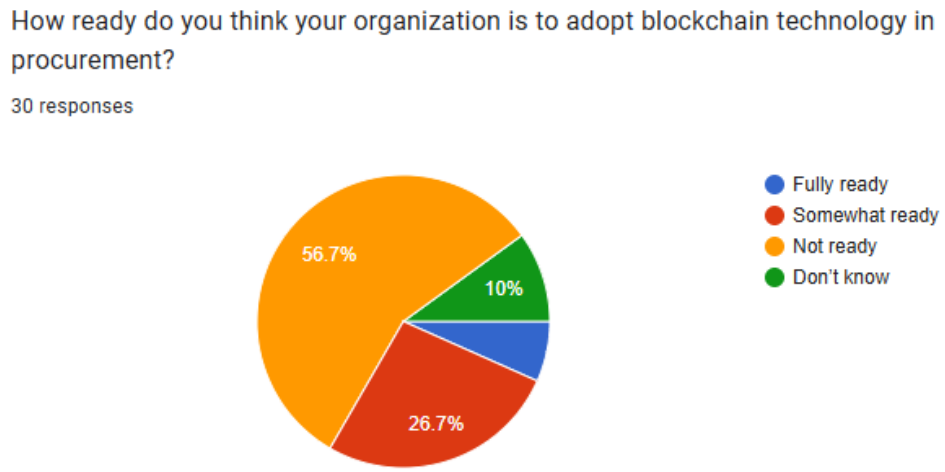

Figure 14: Organizational Readiness for Blockchain Adoption

Major Challenges to Adopting Blockchain in Procurement:

Respondents were asked to identify the key challenges they believe their organization would face in adopting blockchain for procurement. The major challenges identified were:

- **Lack of technical expertise**: 25 respondents highlighted this as a significant barrier. This reflects a common issue faced by organizations looking to adopt emerging technologies, where there is often a shortage of skilled personnel capable of implementing and managing blockchain systems.
- **Resistance to change**: 22 respondents identified organizational resistance as a major challenge. This is typical of industries where traditional processes are entrenched, and change may be perceived as disruptive or risky.
- **Integration with existing systems**: 19 respondents noted that integrating blockchain with current procurement systems could be challenging. This underscores the complexity of transitioning from legacy systems to new technologies, especially when data interoperability and system compatibility are concerns.
- **Regulatory uncertainty**: 14 respondents expressed concerns about the lack of clear regulatory frameworks for blockchain in procurement. Without established legal guidelines, organizations may be hesitant to invest in blockchain-based solutions.
- **High implementation cost**: 13 respondents cited the cost of implementing blockchain as a barrier. Blockchain adoption can require substantial upfront investment in infrastructure, training, and technology development.
- **Don't know**: 4 respondents selected "Don't know," which suggests uncertainty or lack of familiarity with blockchain's potential challenges.

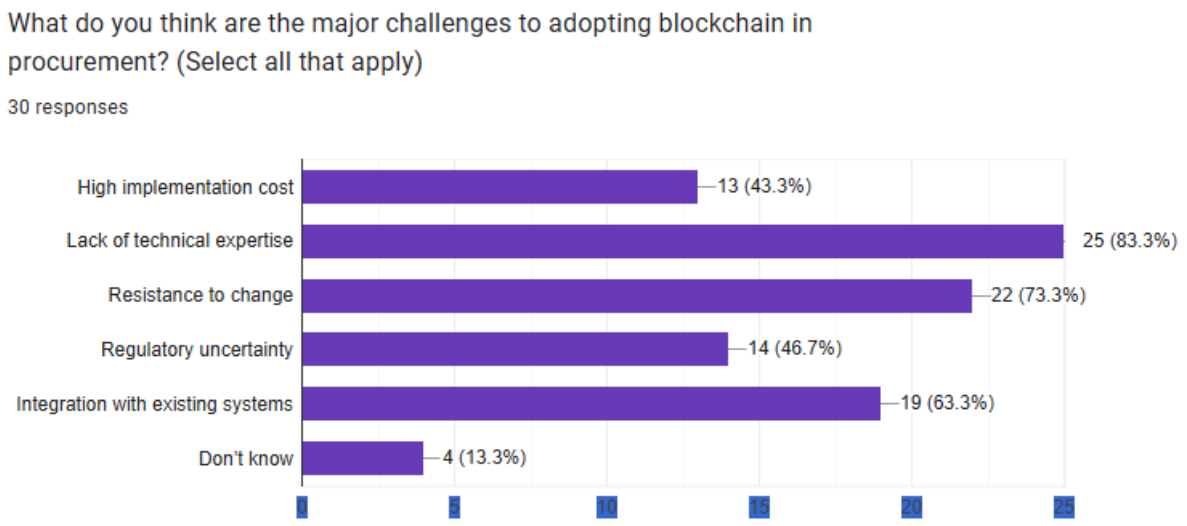

Figure 15: Major Challenges to Adopting Blockchain in Procurement

Expected Benefits of Blockchain in Procurement:

Respondents were asked to identify the benefits of blockchain that would motivate their organization to adopt it for procurement purposes. The results reveal a strong preference for benefits related to security, transparency, and efficiency. The most frequently selected benefit was fraud prevention, with 26 respondents identifying it as a key motivator. This reflects a clear recognition of blockchain's ability to reduce fraud by providing an immutable and transparent record of all transactions. Improved data security followed closely, with 25 respondents seeing blockchain's cryptographic features as crucial for safeguarding sensitive procurement data from unauthorized access or tampering.

In addition to security, respondents also valued blockchain's potential for improving operational efficiency. Faster transaction processing was identified by 17 respondents, highlighting the desire to reduce delays and bottlenecks often encountered in traditional procurement systems. Similarly, better supplier accountability was noted by 16 respondents, emphasizing the benefit of blockchain's traceability features, which make it easier to track and verify supplier performance.

Compliance and audit transparency was also a significant motivator, with 27 respondents selecting it as a key benefit. This underscores the value of blockchain's transparency in regulatory environments, where accurate records are essential for auditing and compliance. On the other hand, cost savings was the least selected benefit, with only 4 respondents

identifying it as a motivator. This suggests that, while cost reduction may be an eventual outcome of blockchain adoption, respondents are more focused on the immediate security, transparency, and efficiency improvements it offers.

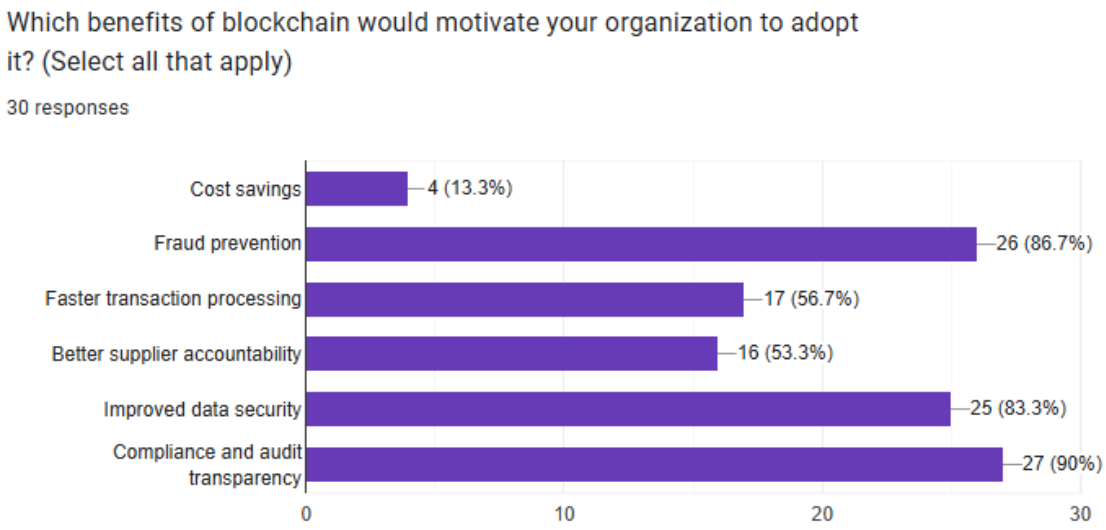

Figure 16: Expected Benefits of Blockchain in Procurement

Support for Blockchain Pilot Project:

When asked whether they would support a pilot project to test blockchain-based procurement in their organization, the majority of respondents expressed their support. This strong endorsement suggests that while there may be uncertainties regarding full-scale adoption, there is a willingness to experiment with blockchain in a controlled, low-risk setting. The fact that very small amount of respondents indicated opposition highlights a general openness towards innovation and technological advancement, particularly when it comes to improving procurement processes. This strong interest in pilot projects indicates that organizations are ready to explore blockchain's potential but may require further evidence of its effectiveness and feasibility before committing to broader implementation.

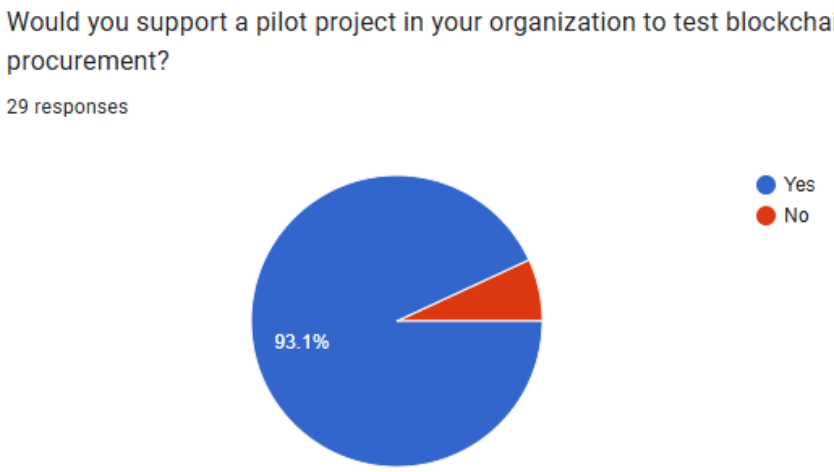

Figure 17: Support for Blockchain Pilot Project

Timeline for Blockchain Adoption in Procurement:

When asked about the timeline for blockchain to become a standard part of procurement in power sector utilities, the majority of respondents (66.7%) indicated that they believe it will take more than 5 years. This suggests that, while there is interest in blockchain, there is also a recognition that significant barriers—such as technical readiness, regulatory approval, and organizational change—will need to be addressed before blockchain can be fully integrated into procurement processes.

A smaller proportion (23.3%) believed blockchain could become standard within 3 to 5 years**,** which reflects a more optimistic outlook, possibly assuming that pilot projects and incremental adoption could pave the way for broader use. Interestingly, no respondents selected the option of blockchain becoming standard within 1 to 3 years, indicating a widespread perception that blockchain's integration into procurement processes will require a longer horizon. Finally, 10% of respondents felt that it was unlikely to happen**,** pointing to skepticism about blockchain's practical feasibility or regulatory support within the power sector.

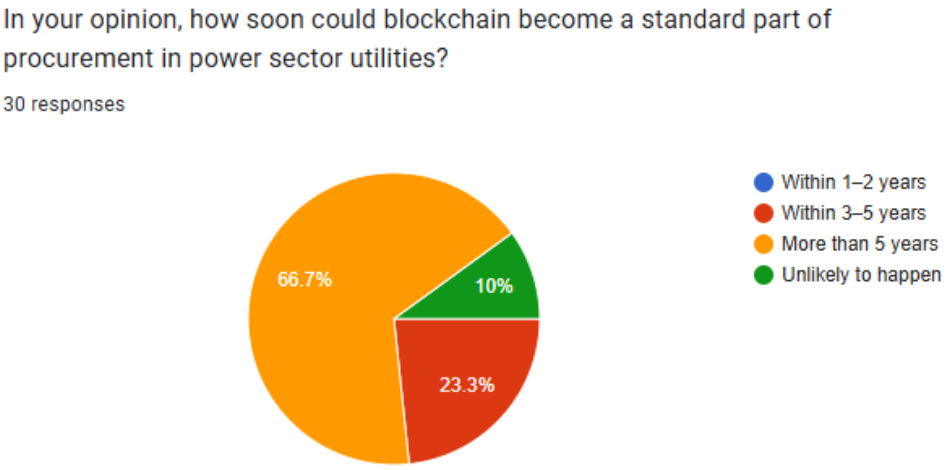

Figure 18: Timeline for Blockchain Adoption in Procurement

7.4 Interpretation and Discussion of Survey Results

The survey results provide significant insights into the perception, readiness, and challenges related to the adoption of blockchain technology in procurement processes, especially in power transmission utilities. These results also highlight how respondents see blockchain's role in enhancing confidentiality and security, which aligns with the core objectives of the thesis.

Blockchain's Benefits: Transparency, Security, and Fraud Prevention

The majority of respondents identified fraud prevention**,** improved data security**,** and compliance and audit transparency as the most compelling benefits of blockchain in procurement. These findings are particularly relevant in the context of KPI areas, where procurement data can be highly sensitive. The respondents strongly recognized blockchain's immutable ledger and cryptographic encryption as tools to ensure that procurement records cannot be altered, which significantly reduces the risk of fraudulent activities.

Respondents also highlighted better supplier accountability and faster transaction processing as key benefits of blockchain. These features are critical in power transmission utilities where accurate and timely procurement of essential equipment is paramount. Blockchain's ability to provide real-time tracking and automated verification of delivery and payment conditions

enhances accountability and reduces the potential for delays or disputes in procurement transactions.

Adoption Challenges: Technical and Organizational Barriers

While the potential benefits are widely acknowledged, the survey results also reveal several challenges that could impede blockchain adoption in procurement systems. Lack of technical expertise was identified as the most significant barrier, with many respondents indicating that organizations may not have the required internal capabilities to implement and manage blockchain systems. This reflects the need for capacity building and specialized training to ensure that employees are equipped to manage blockchain technology.

Another challenge is resistance to change, with many respondents acknowledging that shifting from traditional procurement practices to blockchain-based systems could face significant organizational pushback. Overcoming this resistance will require effective change management strategies, clear communication of blockchain's benefits, and involvement from key stakeholders throughout the implementation process.

Respondents also cited integration with existing systems as a key challenge. This is particularly relevant given that many power transmission utilities still rely on legacy systems, and the transition to blockchain may require significant adjustments to data architecture, workflows, and software infrastructure.

Organizational Readiness: A Need for Preparedness and Strategic Planning

When asked about their organization's readiness to adopt blockchain, the majority of respondents indicated that their organizations were not ready for blockchain adoption. This aligns with the overall findings, which suggest that while there is conceptual support for blockchain, most organizations are not yet prepared to integrate it into their procurement processes. A smaller percentage of respondents indicated that their organizations were somewhat ready, while a very small number felt their organizations were fully ready**.**

This finding reinforces the notion that blockchain adoption in the power transmission sector requires careful strategic planning**,** resource allocation**,** and capacity building to overcome existing barriers. Despite the low readiness levels, respondents showed strong support for

pilot projects, suggesting that organizations are open to testing blockchain in controlled environments to assess its feasibility and effectiveness before full-scale implementation.

Support for Blockchain Pilot Projects

The overwhelming support for pilot projects among respondents indicates a positive outlook for blockchain adoption, even if full integration is seen as a long-term goal. Pilot programs offer an opportunity for utilities to evaluate blockchain's performance in real-world procurement scenarios, while minimizing the risk of large-scale failure. By starting with small-scale projects focused on high-risk procurement processes, power transmission utilities can gradually build confidence and expertise in blockchain technology.

Timeline for Blockchain Adoption: A Long-Term View

Respondents were asked to predict how soon blockchain could become a standard part of procurement in the power sector. The majority (66.7%) indicated that blockchain would take more than 5 years to become a standard practice in procurement. This long-term outlook reflects the challenges of adopting a transformative technology like blockchain in a sector that is often slow to embrace change. Despite this, 23.3% of respondents believed blockchain could become a standard practice within 3 to 5 years, while 10% felt that it was unlikely to happen at all.

This timeline suggests that while blockchain has clear potential in improving procurement processes, its widespread adoption will require overcoming significant technical, organizational, and regulatory hurdles. The extended timeline also highlights the need for a phased approach to adoption, with pilot projects serving as a critical first step.

Conclusion

In conclusion, the survey results align with the broader research objectives of this thesis, reinforcing the importance of blockchain in enhancing security and confidentiality in procurement processes. The recognition of fraud prevention**,** data security**,** and audit transparency underscores blockchain's potential to address vulnerabilities in procurement, especially in the high-risk areas like KPI procurement in power transmission utilities.

However, the survey also highlights that organizational readiness**,** technical expertise, and regulatory uncertainty represent significant barriers to adoption. Despite these challenges, the strong support for pilot projects and the recognition of blockchain's long-term benefits suggest that the power sector is open to exploring blockchain's potential. Moving forward, it is clear that blockchain adoption will require substantial investment in education, organizational change, and phased implementation to ensure its successful integration into procurement systems.

Chapter 8

Implementation Framework and Recommendations

8.1 Proposed Framework for Blockchain Integration in Procurement

The integration of blockchain technology into procurement processes at Power Grid Bangladesh PLC holds significant promise for enhancing security, confidentiality, and transparency. However, to ensure successful adoption, a strategic, phased approach is required. This section proposes a comprehensive framework for blockchain integration into the procurement systems of Power Grid, based on the insights gathered from the survey results and the research objectives of this thesis.

1. Phased Adoption Approach

The integration of blockchain in procurement should follow a phased approach to allow Power Grid to test the technology, identify potential issues, and build confidence within the organization. This approach can be broken down into the following stages:

a. Pilot Program (Year 1–2)

- **Objective**: To test blockchain's feasibility in specific procurement processes at Power Grid Bangladesh PLC.
- **Scope**: Implement blockchain in high-risk procurement areas such as KPI procurement, where confidentiality is paramount. The pilot should focus on document traceability, auditability, and supplier accountability.
- **Actions**:
    - Select a small, manageable procurement process (e.g., tendering or contract management) at Power Grid.
    - Choose a blockchain platform (e.g., permissioned blockchain like Hyperledger Fabric or Ethereum).
    - Collaborate with blockchain experts and IT vendors to facilitate integration with Power Grid's existing procurement systems.
    - Train relevant Power Grid staff on blockchain use and its impact on procurement processes.
    - Monitor and evaluate the pilot for performance, identifying areas for improvement and scalability.

b. Full Integration (Year 3–5)

- **Objective**: To expand blockchain's integration across procurement processes at Power Grid Bangladesh PLC based on the pilot's success.
- **Scope**: Blockchain integration should extend to contract management**,** payment processing**,** and vendor performance tracking**.**
- **Actions**:
    - Scale the pilot to include additional procurement processes and departments at Power Grid.
    - Develop standardized smart contracts to automate procurement agreements and ensure compliance.
    - Implement real-time tracking of goods and services using blockchain for increased supplier accountability**.**
    - Ensure that security measures such as cryptographic encryption and access control are embedded in the system to prevent unauthorized access.

c. Complete Adoption and Continuous Improvement (Year 5 and beyond)

- **Objective**: To achieve full blockchain adoption in procurement processes at Power Grid and ensure long-term sustainability.
- **Scope**: Blockchain should be deeply embedded into all procurement processes at Power Grid, with continuous updates and improvements to match evolving business and regulatory requirements.
- **Actions**:
    - Perform an evaluation of the blockchain system at regular intervals to ensure it is meeting Power Grid's organizational needs.
    - Implement further integration with other enterprise systems, such as ERP and Supply Chain Management (SCM) platforms, to provide a seamless flow of procurement data.
    - Create a feedback loop with employees, suppliers, and stakeholders to constantly improve the system's performance.
    - Focus on regulatory compliance, ensuring that the system meets local and international procurement laws and guidelines.

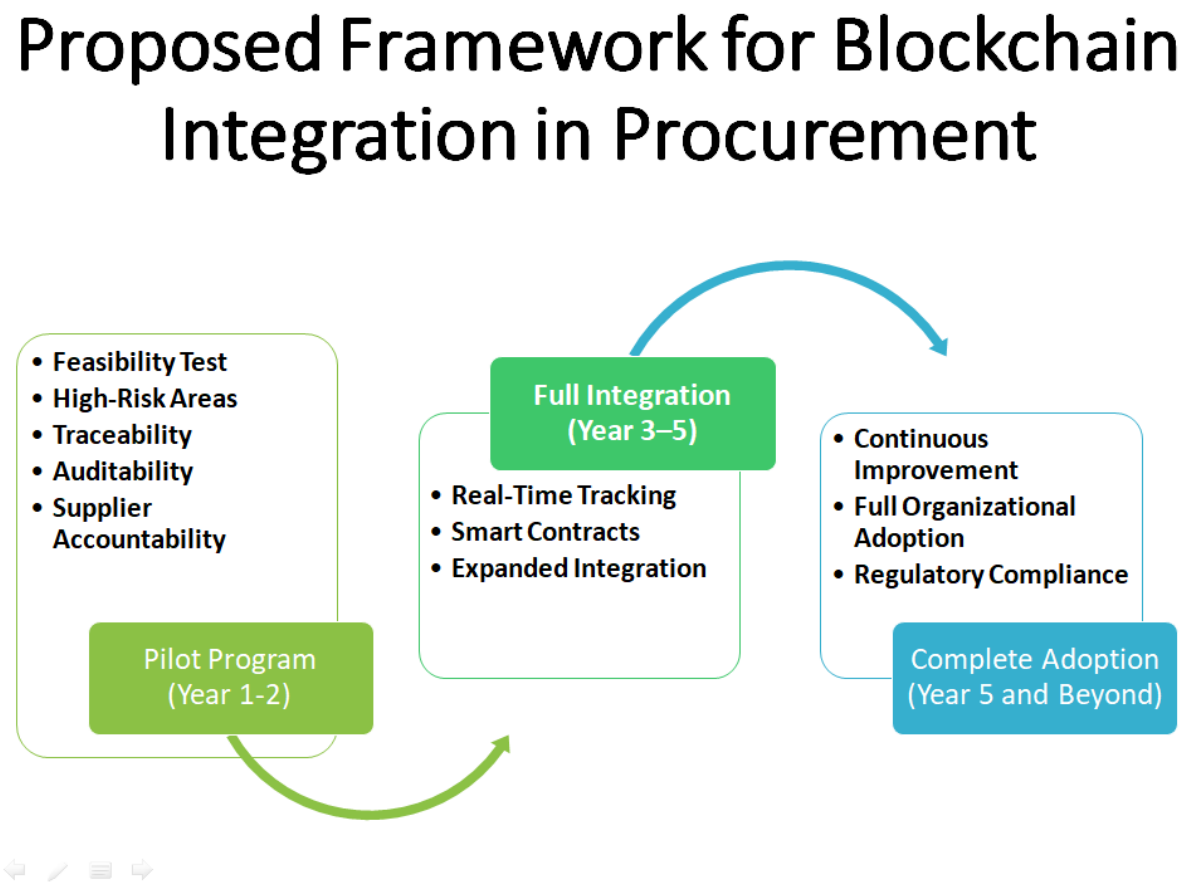

Figure 19: Proposed Framework for Blockchain Integration in Procurement

2. Roles and Responsibilities

Successful implementation of blockchain requires collaboration across various organizational levels within Power Grid Bangladesh PLC. The key stakeholders in the integration framework should include:

- **IT Department**: Responsible for the technical setup, integration with existing systems, and the ongoing maintenance of the blockchain infrastructure.
- **Procurement Team**: Needs to lead the adoption of blockchain in procurement activities at Power Grid, defining the specific processes to be blockchain-enabled and ensuring smooth transitions to digital systems.
- **Regulatory Bodies**: Should provide clear guidelines and support for blockchain adoption in procurement, ensuring that the system aligns with legal and ethical standards.

- **Vendors/Suppliers**: Must be on-boarded to the blockchain system, with appropriate training provided to ensure they understand how the system works and how it benefits their transactions with Power Grid Bangladesh PLC.
- **External Blockchain Consultants**: Can offer expertise and assist with the technical and strategic aspects of blockchain adoption, ensuring the system is customized for the specific needs of Power Grid.

3. Technology Requirements

To facilitate blockchain adoption in procurement, the following technology requirements must be met:

- **Blockchain Platform**: Power Grid Bangladesh PLC should adopt a permissioned blockchain such as Hyperledger Fabric or Ethereum, ensuring data security, scalability, and integration with existing systems.
- **Smart Contracts:** These should be used to automate contract management, eliminating the need for intermediaries and reducing human error.
- **Integration with Existing Systems:** Blockchain must be integrated with ERP systems, supply chain management tools, and other digital procurement platforms to ensure data consistency and seamless workflows.
- **Security Measures:** Strong encryption, secure key management, and role-based access controls are essential for ensuring data confidentiality and preventing unauthorized access to sensitive procurement information.
- **Data Storage and Management:** A robust storage system for blockchain transactions must be set up to ensure auditability and compliance with legal and regulatory standards.

4. Timeline and Milestones

The timeline for blockchain adoption in procurement should be clearly defined with measurable milestones. Below is a proposed timeline with key milestones:

Year 1–2:

- Select pilot project and blockchain platform.
- Complete initial testing and evaluation.

- Provide training for key stakeholders at Power Grid.

Year 3–5:

- Expand blockchain integration to more procurement areas at Power Grid.
- Develop and implement smart contracts.
- Scale the blockchain system to full operational use.

Year 5 and beyond:

- Continuous system evaluation and improvement.
- Full organizational adoption and integration with other enterprise systems.

5. Risk Management and Mitigation

Throughout the adoption process, risk management should be a key focus to minimize disruptions and ensure smooth implementation. Possible risks include:

- **Resistance to change**: Mitigated by providing clear communication, training, and involving stakeholders early in the process.
- **Technical challenges**: Can be addressed by collaborating with experienced blockchain providers and having a dedicated technical team.
- **Regulatory compliance**: Should be ensured by staying up-to-date with changes in procurement laws and involving regulatory bodies in the planning process.

The proposed framework for blockchain integration in procurement provides a strategic, phased approach to adopt blockchain technology in Power Grid Bangladesh PLC. By starting with pilot programs, addressing technical and organizational barriers, and ensuring full integration through careful planning and collaboration, blockchain can significantly enhance procurement processes by improving security**,** confidentiality**,** and transparency. This framework serves as a blueprint for Power Grid Bangladesh PLC to implement blockchain successfully and leverage its full potential in safeguarding sensitive procurement data.

8.2 Recommendations for Utilities, Policymakers, and Stakeholders

As the adoption of blockchain technology in the procurement processes of power transmission utilities, like Power Grid Bangladesh PLC**,** becomes more imminent, it is crucial

to ensure that all stakeholders are prepared to effectively implement, manage, and maximize its potential. This section provides actionable recommendations for utilities, policymakers, and other stakeholders to ensure a smooth transition to blockchain-based procurement systems, focusing on security, confidentiality, and operational efficiency.

Recommendations for Power Transmission Utilities

1. **Invest in Capacity Building and Technical Expertise**

For blockchain adoption to succeed, utilities like Power Grid Bangladesh PLC need to build strong technical expertise within their organizations. Many respondents in the survey highlighted the lack of technical knowledge as a significant barrier to blockchain adoption. To overcome this challenge:

- **Training Programs**: Establish comprehensive training programs aimed at key employees in procurement, IT, and legal departments. These programs should focus on blockchain fundamentals**,** smart contracts**,** and data security**.**
- **Blockchain Champions**: Identify and appoint blockchain champions within the organization who can serve as advocates and experts during the implementation process. These champions can help navigate challenges and mentor others in the organization.

2. Start with Pilot Projects to Demonstrate Value

Rather than attempting a full-scale implementation from the outset, Power Grid Bangladesh PLC should start with pilot projects in high-risk procurement areas such as KPI procurement. This will allow for:

- **Proof of Concept**: Demonstrating blockchain's ability to improve transparency**,** accountability**,** and security in a controlled environment before scaling up.
- **Problem Identification**: Identifying potential challenges related to integration with existing systems, data interoperability, and user adoption on a smaller scale.
- **Stakeholder Engagement**: Engaging internal and external stakeholders (vendors, auditors) early to build confidence and support for blockchain technology.

2. **Develop Robust Regulatory and Compliance Strategies**

The adoption of blockchain for procurement must align with the existing regulatory framework. As the survey identified regulatory uncertainty as a significant barrier, Power Grid Bangladesh PLC should:

- **Work with Regulators**: Collaborate with regulatory bodies to ensure that blockchain systems are compliant with existing procurement laws and regulations, particularly around data protection**,** confidentiality**,** and audit requirements.
- **Create a Blockchain Policy**: Develop an internal blockchain adoption policy that outlines how blockchain will be used across procurement activities, ensures legal compliance, and addresses the ethical use of technology in procurement processes.

4. Focus on Cyber-security and Data Privacy

As cyber-security threats continue to evolve, particularly in sectors dealing with critical infrastructure, utilities must prioritize the implementation of robust security measures within blockchain systems:

- **Data Encryption**: Ensure all procurement data is encrypted both at rest and in transit, utilizing the cryptographic features of blockchain.
- **Access Control**: Implement role-based access controls to restrict access to sensitive procurement data, ensuring that only authorized personnel can view or modify records.
- **Continuous Monitoring**: Set up systems for real-time monitoring of blockchain transactions to detect any anomalies or security breaches quickly.

Recommendations for Policymakers

1. **Create a Supportive Regulatory Framework**

Policymakers must play an active role in fostering the adoption of blockchain technology by creating an enabling regulatory environment:

- **Blockchain-Friendly Regulations**: Establish a **National Blockchain Framework** that encourages its use in public procurement, providing guidelines on data privacy, smart contracts, and digital signatures.

- **Standards for Blockchain Implementation**: Develop industry-specific standards that outline the requirements for implementing blockchain in procurement, ensuring consistency and compliance across organizations.

3. **Provide Financial and Technical Incentives**

To accelerate blockchain adoption, policymakers can provide incentives to both public and private sector entities:

- **Funding for Pilot Programs**: Offer subsidies or grants to support the development and implementation of blockchain pilot programs, especially in high-risk sectors like power transmission.
- **Tax Incentives for Innovation**: Provide tax incentives or reduced tariffs for utilities and technology providers that invest in blockchain solutions for procurement, making it more financially viable for companies to adopt the technology.

4. **Promote Public-Private Partnerships (PPPs)**

Public-private partnerships can drive innovation in the adoption of blockchain for procurement. Policymakers should:

- **Facilitate Collaboration**: Encourage collaboration between blockchain technology providers**,** utilities**,** and government agencies to design, implement, and scale blockchain solutions.
- **Testbed Programs**: Establish testbed programs where utilities can experiment with blockchain solutions in a controlled, regulatory-compliant environment, helping to build trust and refine the technology.

Recommendations for Other Stakeholders (Vendors, Blockchain Providers, Academia)

1. Vendors: Embrace Blockchain and Digital Transformation

Vendors, who are key players in the procurement process, should be encouraged to:

- **Adopt Blockchain Solutions**: Begin integrating blockchain technology into their own procurement systems to ensure seamless interaction with utility companies. This will

allow vendors to automate contract execution, secure payments, and improve accountability in their transactions with Power Grid Bangladesh PLC.

- **Collaboration with Utilities**: Work closely with utilities to ensure system compatibility and provide support during the implementation phase, ensuring that blockchain technology is adopted smoothly.

2. Blockchain Providers

Blockchain providers should focus on customizing Solutions for the Power Sector. Blockchain technology providers should develop tailored solutions for the power sector's procurement needs:

- **Power Sector-Specific Features**: Incorporate industry-specific features such as real-time monitoring of energy-related equipment and automated compliance reporting into their blockchain solutions.
- **Training and Support**: Provide extensive training and technical support to utilities during the implementation phase, helping them to integrate blockchain into their existing procurement systems and ensure smooth operation.

3. Academia: Drive Research and Development

Academic institutions can play an important role by:

- **Conducting Research**: Investigating the effectiveness of blockchain in enhancing procurement processes, specifically in the power sector. Research could focus on case studies, technical improvements, and regulatory challenges.
- **Curriculum Development**: Offering specialized programs and courses in blockchain for supply chain management and digital procurement, preparing the next generation of professionals to understand and implement these technologies.

The successful adoption of blockchain technology in the procurement processes of Power Grid Bangladesh PLC and other utilities depends on the collaboration of utilities, policymakers, and other stakeholders. By investing in capacity building, pilot projects, and regulatory alignment, utilities can effectively implement blockchain to improve security, confidentiality, and transparency in procurement. Policymakers should provide the necessary regulatory framework and incentives, while stakeholders such as vendors, blockchain

providers, and academia must work together to ensure the technology is implemented effectively and sustainably.

8.3 Conclusion and Future Outlook

The integration of blockchain technology into procurement processes, particularly in power transmission utilities like Power Grid Bangladesh PLC, has the potential to enhance confidentiality, security, and transparency. This research has successfully addressed the primary objectives, which aimed at exploring how blockchain could be utilized to overcome some of the key challenges faced by the power sector in Bangladesh, such as fraud, inefficiency, and lack of transparency in procurement processes.

The findings from the survey and subsequent analysis highlight that blockchain's core features such as its immutable ledger**,** real-time traceability**,** and cryptographic security measures which can play a significant role in maintaining the confidentiality of sensitive data in high-risk procurement fields like KPI areas. By ensuring that procurement data such as equipment specifications and vendor details remain secure and tamper-proof, blockchain can reduce the risk of cyber-attacks, like those seen in the Stuxnet incident, where sensitive procurement information was exploited to target critical infrastructure.

The framework and roadmap proposed in this research offer a structured approach for Power Grid Bangladesh PLC to integrate blockchain into its procurement systems. Starting with pilot projects, utilities can test blockchain's effectiveness in improving procurement processes and gradually scale up based on the lessons learned. This approach allows for a controlled and measured transition, ensuring that any challenges can be addressed at an early stage before full-scale adoption.

Furthermore, the research has successfully demonstrated that blockchain can not only improve procurement transparency but also create automated audit trails that ensure compliance with regulatory standards. These features align with the sector's growing need for secure, verifiable, and transparent procurement practices that can stand up to scrutiny from both internal auditors and external regulators.

Future Outlook

As the implementation of blockchain technology in procurement processes continues to evolve, there are several key areas where future development and research can further enhance its impact:

1. **Expansion across the Sector**

While this research primarily focused on Power Grid Bangladesh PLC**,** the integration of blockchain can be extended to other utilities and critical infrastructure sectors. As blockchain adoption matures, a sector-wide shift can be expected, where public and private utilities collaborate to standardize blockchain protocols and ensure interoperability across different systems.

2. **Integration with Other Emerging Technologies**

Blockchain's potential extends beyond procurement. Integration with other emerging technologies, such as Internet of Things (IoT) and Artificial Intelligence (AI)**,** could create more intelligent procurement systems [17]. For example, IoT-enabled devices can continuously monitor the status of procured equipment, while AI-powered systems can analyze blockchain data to predict maintenance needs or optimize inventory management.

3. **Regulatory Adaptation and Innovation**

As blockchain adoption increases, there will be a growing need for regulatory bodies to update and create policies that govern its use in procurement. Policymakers should work closely with utilities to establish a comprehensive regulatory framework that addresses issues related to data privacy**,** contract automation**,** and cross-border transactions. Additionally, utilities will need to ensure their blockchain solutions are compliant with both national and international standards.

4. **Wider Industry Adoption**

The energy sector globally is beginning to explore blockchain for various functions, from energy trading to supply chain management. The lessons learned from international case studies can be valuable to utilities in Bangladesh as they explore further blockchain

integration. As more real-world applications of blockchain are developed in energy and infrastructure sectors, Power Grid Bangladesh PLC and other utilities can draw from these best practices to overcome challenges and streamline their adoption efforts.

5. **Long-Term Sustainability and Continuous Improvement**

In the long run, blockchain can serve as the backbone for a fully digital procurement ecosystem. The adoption of blockchain should not be viewed as a one-time implementation but as part of a broader digital transformation journey. Continuous evaluation, monitoring, and adaptation will be crucial to address emerging threats and evolving market demands. The successful integration of blockchain can lead to the creation of an agile, transparent, and efficient procurement system that not only ensures security but also fosters innovation and adaptability. Moreover, blockchain provides a framework for traceability allowing for the tracking of products from raw materials to final delivery. This level of transparency ensures that products meet the required environmental**,** social**,** and economic sustainability criteria [18]. Such capabilities enable utilities to make more informed decisions, align with sustainability goals, and improve public and consumer trust, which is vital for long-term growth in the energy sector. The potential of blockchain technology to support long-term sustainability extends beyond procurement and into broader environmental goals. As highlighted by Future Thinkers (2021)**,** blockchain's inherent capabilities such as transparency**,** immutability**,** and traceability can enhance supply chain management by making it more transparent, sustainable and accountable [19]. In the context of power transmission utilities like Power Grid Bangladesh PLC, blockchain could be employed to ensure ethical sourcing and environmental sustainability in procurement, particularly in KPI procurement, where tracking the environmental impact of materials and equipment is crucial. By utilizing blockchain, utilities can verify the sustainability of their suppliers and ensure that products meet environmental standards, reducing waste and inefficiency.

6. **Enhancing Supplier and Vendor Relationships**

Blockchain's ability to provide real-time, transparent tracking of goods and services can significantly enhance the relationship between Power Grid Bangladesh PLC and its suppliers. With automated payment processing through smart contracts and clear visibility into each stage of the procurement process, blockchain can help build trust and accountability. This can result in stronger long-term partnerships and improved service delivery, benefiting both

utilities and their vendors. A study by Sridhar Yerram (2022) highlights that organizations can significantly enhance supplier relationships through the use of blockchain and smart contracts. The author argue that these technologies foster a secure and transparent transaction environment, promote collaboration among supply chain actors, and encourage innovation by building trust and reducing friction in interactions [20].

In conclusion, the potential for blockchain to revolutionize procurement in power transmission utilities is vast. The ability of blockchain to ensure confidentiality**,** data integrity**,** and auditability will help utilities address existing procurement inefficiencies while reducing the risks of cyber-attacks and fraud. However, successful adoption will depend on strategic planning**,** pilot testing**,** and cross-sector collaboration to address the challenges of technical expertise, resistance to change, and regulatory adaptation.

The future of blockchain in procurement is bright, and its continued evolution presents an opportunity for power transmission utilities to embrace new technologies that will improve operational efficiency, enhance security, and contribute to the long-term sustainability of energy infrastructure.

References

[1] International Energy Agency (IEA), "World Energy Investment Report, 2023".

[2] Andoni, M., et al., "Blockchain Technology in the Energy Sector: A Systematic Review," Renewable and Sustainable Energy Reviews, 2019.

[3] Langner, R., "Stuxnet: Dissecting a Cyberwarfare Weapon," IEEE Security & Privacy, 2011.

[4] G. White and P. Sloan, “Smart Contracts in Public Procurement: A Framework for Legal and Operational Risk Mitigation,” *Journal of Strategic Contracting and Negotiation*, vol. 4, no. 2, pp. 150-165, 2018.

[5] M. D. Crosby, P. Pattanayak, S. Verma, and V. Kalyanaraman, “Blockchain Technology: Beyond Bitcoin,” *Applied Innovation Review*, vol. 2, pp. 6–19, 2016.

[6] https://www.hitachi.com/New/cnews/month/2021/03/210303a.html#:~:text=Tokyo%2C%20March%203%2C%202021%20%2D,in%20Japan%20after%20July%202021.

[7] https://www.lfdecentralizedtrust.org/case-studies/techmahindra-case-study

[8] Babu George (2024), "Blockchain in Global Trade: Insights from the TradeLens Experiment".

[9] https://www.spgroup.com.sg/about-us/media-resources/energy-hub/innovation/world-s-first-blockchain-powered-rec-marketplace

[10] Francisco, K., & Swanson, D. (2018). “The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency.”

[11] World Economic Forum. (2020). *Redesigning Trust: Blockchain Deployment Toolkit*.

[12] IBM Institute for Business Value. (2021). *Blockchain for procurement: Shaping the future of supply integrity*.

[13] Zheng, Z., Xie, S., Dai, H.-N., Chen, X., & Wang, H. (2018). Blockchain challenges and opportunities: A survey. *International Journal of Web and Grid Services, 14*(4), 352-375.

[14] Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System.

[15] PricewaterhouseCoopers (PwC), "Annual Report 2017".

[16] Saunders, M., Lewis, P., & Thornhill, A. (2019). Research Methods for Business Students (8th Edition). Pearson Education.

[17] Rejeb, A., Keogh, J. G., & Treiblmaier, H. (2019). Leveraging the internet of things and blockchain technology in supply chain management. *Future Internet*, *11*(7), 161.

[18] Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research, 57*(7), 2117-2135.

[19] futurethinkers. 2017. “7 Ways The Blockchain Can Save The Environment and Stop Climate Change.” http://futurethinkers.org/blockchain-environment-climate-change/.

[20] Sridhar Yerram (2022), "Smart Contracts for Efficient Supplier Relationship Management in the Blockchain".

Appendix A.

Survey Questionnaire on Exploring Blockchain Adoption

Dear Respondent,

This survey aims to assess the understanding, adoption, and challenges of blockchain technology in procurement and supply chain management within power transmission utilities in Bangladesh, with a focus on Power Grid Bangladesh PLC. The goal is to gather insights into how blockchain can enhance transparency, security, and efficiency in procurement processes.

Your participation will provide valuable data for the research and help in developing a framework for blockchain adoption in procurement. Rest assured that all responses will be kept confidential and will be used exclusively for academic and research purposes. No personal information will be shared, and the data will be analyzed in aggregate.

We appreciate your time and cooperation in completing this survey.

Thank you for your valuable input.

Survey Questionnaire on Exploring Blockchain Adoption in Procurement

* Indicates required question

1. How many years of experience do you have in procurement or supply chain-related roles? *

Mark only one oval.

- ◯ Less than 1 year
- ◯ 1–3 years
- ◯ 4–7 years
- ◯ More than 7 years

2. How would you define your level in the current position? *

Mark only one oval.

- ◯ Director / Executive level
- ◯ Senior Manager
- ◯ Mid-level Manager
- ◯ Entry-level / Trainee

3. How familiar are you with the concept of blockchain technology? *

Mark only one oval.

- ◯ Very familiar
- ◯ Somewhat familiar
- ◯ Heard of it but don't know much
- ◯ Not familiar at all

4. Which of the following features do you associate with blockchain technology? (Select all that apply) *

Check all that apply.

- [ ] Immutability
- [ ] Secured Procurement
- [ ] Streamlining Procurement
- [ ] Real-time tracking
- [ ] Decentralization
- [ ] Don't know / Not sure

5. To what extent do you agree with the following statement: "Blockchain can increase transparency in procurement processes." *

Mark only one oval.

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

6. To what extent do you agree with the following statement: "Blockchain can reduce corruption and manipulation in public procurement." *

Mark only one oval.

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

7. Do you think blockchain technology can help ensure confidentiality when purchasing sensitive or classified equipment/tools? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

8. Which procurement stages could benefit most from blockchain implementation? (Select all that apply) *

Check all that apply.

- ☐ Vendor selection
- ☐ Tendering and bidding
- ☐ Contract execution
- ☐ Delivery tracking
- ☐ Payment processing

9. Does your organization currently use any digital tools in procurement? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Not Sure

10. How ready do you think your organization is to adopt blockchain technology in procurement? *

Mark only one oval.

- ◯ Fully ready
- ◯ Somewhat ready
- ◯ Not ready
- ◯ Don't know

11. What do you think are the major challenges to adopting blockchain in procurement? (Select all that apply) *

Check all that apply.

- ☐ High implementation cost
- ☐ Lack of technical expertise
- ☐ Resistance to change
- ☐ Regulatory uncertainty
- ☐ Integration with existing systems
- ☐ Don't know

12. Which benefits of blockchain would motivate your organization to adopt it? (Select all that apply) *

Check all that apply.

- ☐ Cost savings
- ☐ Fraud prevention
- ☐ Faster transaction processing
- ☐ Better supplier accountability
- ☐ Improved data security
- ☐ Compliance and audit transparency

13. Would you support a pilot project in your organization to test blockchain-based procurement?

Mark only one oval.

- ◯ Yes
- ◯ No

14. In your opinion, how soon could blockchain become a standard part of procurement in power sector utilities? *

Mark only one oval.

- ◯ Within 1–2 years
- ◯ Within 3–5 years
- ◯ More than 5 years
- ◯ Unlikely to happen