REDUCING THE SYSTEM LOSS OF GAS DISTRIBUTION SYSTEM IN BANGLADESH

By

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of the requirements for the degree of
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Declaration

It is hereby declared that

1. The thesis submitted is my 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 have acknowledged all main sources of help.

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Approval

The thesis/project titled "**Reducing the System Loss of Gas Distribution System in Bangladesh**" submitted by

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of **Summer Semester**, **2025** has been accepted as satisfactory in partial fulfillment of the requirement for the degree of **Master of Arts in Governance and Development (MAGD)]** on 18th November 2025.

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Ethics Statement

This research was carried out in alignment with the ethical standards and academic integrity guidelines established by the BRAC Institute of Governance and Development (BIGD), BRAC University.

All data utilized in this study were sourced from publicly accessible materials, institutional reports, and with the necessary permissions from the appropriate authorities. In instances where interviews or consultations were held with stakeholders (including officials from Petrobangla and gas distribution companies such as TGTDCL, BGDCL, KGDCL, JGTDSL, PGCL, and SGCL), prior informed consent was secured. The identities of individual participants have been kept confidential, and their responses have been utilized exclusively for academic purposes.

No aspect of this study involved any form of deception, coercion, or harm to participants. The research did not engage any vulnerable populations or sensitive personal data. All requisite measures were taken to ensure the voluntary and informed participation of all individuals involved.

This thesis does not contain any material that infringes copyright laws or misrepresents any data. Any external sources of data or information employed have been properly acknowledged and cited in accordance with standard guidelines.

The researcher asserts that the study adheres to the principles of honesty, transparency, and respect for intellectual and human rights in all facets of data collection, analysis, and reporting.

Abstract

Bangladesh's reliance on natural gas, providing over 60% of total energy, faces a significant challenge: persistent system loss in its distribution network. These losses, caused by technical inefficiencies, illegal connections, metering inaccuracies, and pipeline leaks, contribute to energy insecurity, financial instability for state-owned gas companies, and environmental degradation through methane emissions.

Despite a range of interventions, Bangladesh has not achieved a sustained reduction in gas distribution losses. This policy note synthesizes existing research and field interviews to analyze the drivers of system loss and recommend a feasible multi-dimensional strategy integrating technological, regulatory, financial, and institutional reforms. Drawing on domestic data and international case studies, this note proposes a roadmap focused on actionable solutions aligned with national energy goals and international sustainability commitments.

Bangladesh's gas distribution system suffers from persistent and escalating system losses, ranging from 7.5% to 14% markedly higher than the global benchmark of 2%. These losses represent not only a financial burden (≈ Tk 800 billion/year) but also a significant threat to the country's energy security, industrial productivity, and climate commitments under SDG 7 and SDG 13.

Keywords: System loss; energy security; energy goals; sustainability commitments; industrial productivity; climate commitments.

Dedication

This thesis is lovingly dedicated to:

My parents Mr. Ershad Uzzaman & Mrs. Shamsun Nahar, my spouse Dr. Naima Binte Shokrana, my daughter Manha Tahsin Zaman & my son Farhat Zaman, whose unwavering love, endless support, and constant encouragement have been the bedrock of my academic journey. Their sacrifices and belief in my abilities have fueled my every step.

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List of Acronyms

ADB: Asian Development Bank

AfDB: African Development Bank

AI: Artificial Intelligence

BERC: Bangladesh Energy Regulatory Commission

BGDCL: Bakhrabad Gas Distribution Company Ltd.

BGEF: Bright Green Energy Foundation

BPDB: Bangladesh Power Development Board

BSRM: Bangladesh Steel Re-Rolling Mills Limited

BUET: Bangladesh University of Engineering and Technology

CDM: Clean Development Mechanism

CNG: Compressed Natural Gas

CO_2-eq: Carbon Dioxide equivalent

CPD: Centre for Policy Dialogue

DNV: Det Norske Veritas (a global assurance and risk management company)

EPZ: Export Processing Zone

EU: European Union

FY: Fiscal Year

GDP: Gross Domestic Product

HCU: Hydrocarbon Unit

HDPE: High-Density Polyethylene

IoT: Internet of Things

JGTDSL: Jalalabad Gas Transmission and Distribution System Ltd.

KGDCL: Karnaphuli Gas Distribution Company Ltd.

LNG: Liquefied Natural Gas

LPG: Liquefied Petroleum Gas

MIT: Massachusetts Institute of Technology

MMCFD: Million Cubic Feet per Day

MMCM: Million Cubic Meter

NDCs: Nationally Determined Contributions

PB: Bangladesh Oil, Gas & Mineral Corporation (Petrobangla)

PGCL: Pashchimanchal Gas Company Ltd.

PHMSA: Pipeline and Hazardous Materials Safety Administration

PLC: Public Limited Company

PPPs: Public-Private Partnerships

PSI: Pounds per Square Inch

Q1: Quarter 1

QRM: Quantitative Risk Management

SCADA: Supervisory Control and Data Acquisition

SDG: Sustainable Development Goals

SGCL: Sundarban Gas Company Ltd.

SWOT Analysis: Strengths, Weaknesses, Opportunities, and Threats Analysis

TGTDPLC: Titas Gas Transmission and Distribution Public Limited Company

Tk: Bangladeshi Taka (currency)

UFG: Unaccounted for Gas

UNDP: United Nations Development Programme

US: United States

m - meter

m^2 - Meter Square

m^3- Cubic Meter

ft- feet

^oC - Degree Celsius

$ - Dollar

% - Percentage

> - Greater Than

< - Less Than

Glossary

Asian Development Bank	A regional development bank that facilitates economic development in Asia.
African Development Bank	A multilateral development finance institution established to contribute to the economic development and social progress of African countries.
Artificial Intelligence	The simulation of human intelligence in machines that are programmed to think like humans and mimic their actions.
Bangladesh Energy Regulatory Commission	The autonomous independent statutory state Quasi-judicial body established in 2003 to regulate the energy sector in Bangladesh, including electricity, gas, and petroleum.
Bakhrabad Gas Distribution Company Ltd.	A state-owned natural gas distribution company of Bangladesh responsible for supplying natural gas in South-eastern part (Brahman Baria, Greater Noakhali, Cumilla & Chandpur region) of Bangladesh.
Bright Green Energy Foundation	An organization involved in promoting solar home systems.
Bangladesh Power Development Board	A government-owned power utility in Bangladesh.
Bangladesh Steel Re-Rolling Mills Limited	A steel manufacturing company.
Bangladesh University of Engineering and Technology	The oldest & largest public engineering university in Bangladesh.
Clean Development Mechanism	An international offset scheme under the Kyoto Protocol that allows developed countries to earn emission reduction credits from emission-reduction projects in developing countries.
Compressed Natural Gas	A fuel gas mainly composed of methane (CH4), compressed to less than 1% of the volume it occupies at standard atmospheric pressure. It is stored and distributed in hard containers at a pressure of 20–25 megapascals (2,900–3,600 psi; 200–250 bar), usually in cylindrical or spherical shapes.

CO_2-eq (Carbon Dioxide equivalent)	A metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide.
Centre for Policy Dialogue	A civil society think tank in Bangladesh.
Det Norske Veritas	An international accredited registrar and classification society headquartered in Norway. DNV provides services for several industries, including maritime, oil and gas, renewable energy, electrification, and healthcare.
Export Processing Zone	A designated area in a country with special economic regulations to encourage industrial and commercial exports.
European Union	A supranational political and economic union of 27 member states located primarily in Europe.
Fiscal Year	A 12-month period used for financial reporting by governments and businesses.
Gross Domestic Product	The total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period.
Hydrocarbon Unit	A unit related to hydrocarbons, often in the context of energy or petroleum.
High-Density Polyethylene	A durable thermoplastic polymer made from petroleum, commonly used for pipelines.
Internet of Things	The network of physical objects embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data over the internet.
Jalalabad Gas Transmission and Distribution System Ltd.	A state-owned natural gas transmission and distribution company of Bangladesh responsible for supplying natural gas in Sylhet Division of Bangladesh.
Karnaphuli Gas Distribution Company Ltd.	A state-owned natural gas distribution company of Bangladesh responsible for supplying natural gas in greater Chittagong region of Bangladesh.
Liquefied Natural Gas	Natural gas (predominantly methane, CH4, with some mixture of ethane, C2H6) that has been cooled to liquid form for ease and safety of non-pressurized storage or

	transport. It takes up about 1/600th the volume of natural gas in the gaseous state at standard temperature and pressure.
Liquefied Petroleum Gas	A flammable mixture of hydrocarbon gases used as fuel. LPG has a wide variety of uses in many different markets as an efficient fuel container in the agricultural, recreation, hospitality, industrial, construction, sailing and fishing sectors. It can serve as fuel for cooking, central heating and water heating and is a particularly cost-effective and efficient way to heat off-grid homes.
Massachusetts Institute of Technology	A private research university in Cambridge, Massachusetts. Established in 1861, MIT has played a significant role in the development of many areas of modern technology and science.
Million Cubic Feet per Day	A unit used to measure the volume of natural gas flow. Commonly used as a measure of natural gas, liquefied petroleum gas, compressed natural gas and other gases that are extracted, processed or transported in large quantities.
Million Cubic Meter	A unit of volume, typically used for gas.
Nationally Determined Contributions	Commitments that countries make to reduce their greenhouse gas emissions as part of climate change mitigation. These commitments include the necessary policies and measures for achieving the global targets set out in the Paris Agreement.
Paris Agreement	The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 195 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. It entered into force on 4 November 2016. Has a long-term temperature goal which is to keep the rise in global surface temperature to well below 2 °C (3.6 °F) above pre-industrial levels. The treaty also states that preferably the limit of the increase should only be 1.5 °C (2.7 °F). These limits are defined as averages of the global temperature as measured over many years.
Petrobangla	The government owned oil, gas and mineral corporation of Bangladesh. It has the mandate to explore, produce, transport, manage and sell oil, natural gas and other mineral resources. It also concludes production-sharing agreements with international oil companies for exploration and development of oil, gas and mineral resources in Bangladesh. Established on 26 March 1972.

	It has 13 subsidiary Companies.
Pashchimanchal Gas Company Ltd.	A state-owned natural gas distribution company of Bangladesh responsible for supplying natural gas in the north-western part of Bangladesh.
Pipeline and Hazardous Materials Safety Administration	A United States Department of Transportation agency created in 2004, responsible for developing and enforcing regulations for the safe, reliable, and environmentally sound transportation of energy and other hazardous materials.
Public Limited Company	A type of company that can offer its shares to the public.
Public-Private Partnerships	A long-term contract between a private party and a government entity for providing a public asset or service.
Pounds per Square Inch	A unit of pressure.
Quarter 1	The first quarter of a fiscal year.
Quantitative Risk Management	A process used to analyze and measure risks using numerical and statistical methods.
Supervisory Control and Data Acquisition	A control system architecture that uses computers, networked data communications, and graphical user interfaces for high-level process supervisory management.
Sustainable Development Goals	A collection of 17 interlinked global goals designed to be a “blueprint to achieve a better and more sustainable future for all” by the United Nations.
Sundarban Gas Company Ltd.	A state-owned natural gas distribution company of Bangladesh responsible for supplying natural gas in Khulna Division, Barishal Division, and the greater Faridpur region of Bangladesh.
SWOT analysis	A strategic planning tool used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a project or organization. It helps businesses or individuals understand their current position and make informed decisions about future strategies.
Titas Gas Transmission and Distribution Public Limited Company	A state-owned natural gas transmission and distribution company of Bangladesh responsible for supplying natural gas in Greater Dhaka and Greater Mymensingh Division of Bangladesh.

Tk (Taka)	The currency of Bangladesh.
Unaccounted for Gas	Gas that is supplied into a system but not billed to consumers, representing losses.
United Nations Development Programme	A United Nations agency tasked with helping countries eliminate poverty and achieve sustainable economic growth and human development. Emphasizes on developing local capacity towards long-term self-sufficiency and prosperity.

Chapter 1

Introduction

1.1 Background and Context

Natural gas plays a vital role in the energy framework of Bangladesh, contributing approximately 63% to electricity generation, facilitating industrial growth, and serving as an essential component in the production of fertilizers and domestic consumption. The gas sector, characterized by over 4 million registered consumers and six major distribution companies, is extensive and critical to the nation's economy. However, despite an increasing reliance on imported liquefied natural gas (LNG), which constitutes 25% of the total supply, Bangladesh continues to face a worsening crisis related to system losses. These losses, defined as the unaccounted volume of gas from the purchase point to the sale point, are projected to reach 9.97% by 2025, significantly exceeding the global benchmarks of 1.5-2%. The Bangladesh Energy Regulatory Commission (BERC) estimates that these losses result in an economic burden of Tk 800 billion annually, which is approximately 0.6% of the country's GDP. If the proposed reforms are successfully enacted, they could yield annual savings of over Tk 400 billion, a decrease in methane emissions by 7.7 million tons CO_2-eq, and enhanced resilience within the industrial sector.The issue is complex and systemic. Factors contributing to this include:

• Challenges related to the deterioration of pipeline systems;

• Outdated and malfunctioning metering devices;

• Common occurrences of illegal connections and unauthorized consumption;

• Insufficient enforcement, accountability protocols, and institutional oversight.

Moreover, the distribution of losses is not uniform across the nation or among various companies. For instance, BGDCL and KGDCL recorded system losses of 10.06% and 3.24% respectively for the fiscal year 2023-24, whereas SGCL and PGCL exhibit significantly less fluctuation, attributed to efficient regulation and upgraded infrastructure.

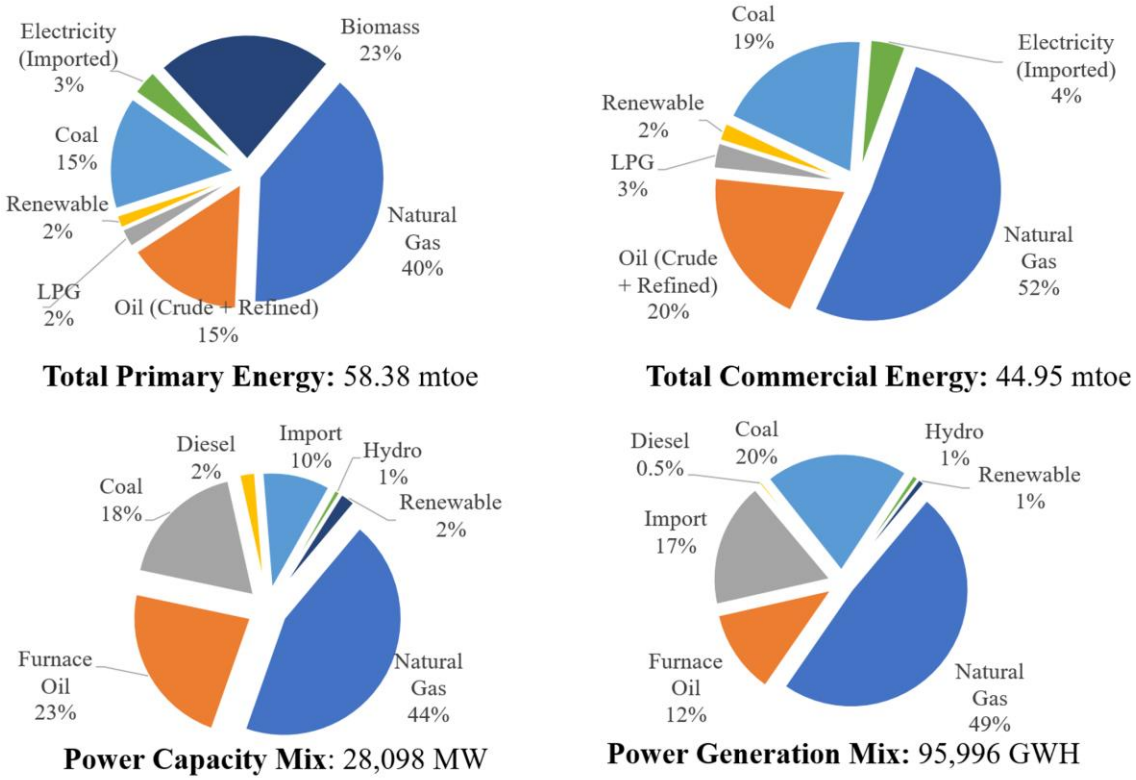


Fig1: Energy Mix Scenario (2023-24)
Source: Energy Scenario of Bangladesh 2023-24, HCU & BPDB Annual Report 2023-24

This policy note evaluates the root causes, institutional bottlenecks, and technical inefficiencies contributing to system loss across six gas distribution companies of Bangladesh:

- Titas Gas Transmission and Distribution Public Limited Company (TGTDCPLC)
- Bakhrabad Gas Distribution Company Ltd. (BGDCL)
- Karnaphuli Gas Distribution Company Ltd. (KGDCL)
- Jalalabad Gas Transmission and Distribution System Ltd. (JGTDSL)
- Pashchimanchal Gas Company Ltd. (PGCL)
- Sundarban Gas Company Ltd. (SGCL)

1.2 Problem Statement

Despite various initiatives, including the installation of prepaid gas meters, the modernization of pipelines, and anti-theft campaigns, Bangladesh has made only minimal strides in sustainably reducing system losses. The current efforts are characterized by:

- Fragmented design and implementation;
- A reactive rather than proactive approach;
- Insufficient funding and political constraints.

Furthermore, the lack of real-time monitoring, limited coordination among stakeholders, and resistance from powerful interest groups have hindered the effectiveness of policies. As the industrial sector becomes increasingly dependent on gas supplies and global LNG prices continue to escalate, addressing system losses has emerged as both an urgent economic imperative and a strategic necessity.

1.3 Research Objectives

This policy note seeks to:

- Conduct a quantitative analysis of system loss data from 2019 to 2024 for 6 gas distribution companies of Bangladesh.
- Determine the underlying causes-technical, institutional, and financial of persistent losses.
- Assess the success of previous interventions through cost-benefit and regression analyses.
- Create a detailed, phased policy plan aimed at decreasing losses to 5% or less by the year 2030.

1.4 Research Questions

1. What are the primary causes of system loss in the gas distribution network?
2. What are the most effective strategies to mitigate these losses?
3. How can technological innovations and policy frameworks be combined to ensure sustainable solutions?

1.5 Significance of the Study

This note aligns with Bangladesh's national and international development goals, including:

- SDG 7: Ensuring access to affordable, dependable, and contemporary energy;
- SDG 13: Implementing urgent measures to address climate change and its effects;
- Transformation: Elevating Bangladesh to an upper-middle-income nation through the modernization of infrastructure and the expansion of industry.

By offering evidence-based, actionable recommendations, this study serves policymakers, regulators, utility managers, and international development partners committed to building a more efficient and transparent energy sector.

Chapter 2

Literature Review

2.1 Global Best Practices in Gas Distribution Efficiency

Around the world, successful approaches to minimizing system losses in natural gas distribution have focused on three main areas: technological innovation, robust regulatory frameworks, and performance-oriented infrastructure investments. In the United States, for instance, system losses have been cut to below 2% thanks to upgrades in metering systems, risk-based integrity management, and tighter federal regulations. The American Gas Foundation points out that advancements in leak detection technology, material improvements (such as the use of polyethylene pipes), and maintenance driven by data have enhanced safety and efficiency in distribution networks. Additionally, the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) underscores the importance of tackling mechanical damage through proactive technical audits and strategies for mitigation. Within the European Union, both DNV (2022) and the European Court of Auditors (2024) advocate for repurposing outdated infrastructure (for example, for hydrogen blending or biogas injection) when it becomes economically impractical to mitigate losses. Moreover, countries such as Germany and Denmark have utilized SCADA systems and AI-assisted gas mapping to continuously monitor unaccounted-for gas (UFG) in real-time. An evaluation by the African Development Bank (2015) of Tunisia's gas network illustrates how regional development banks can support hybrid infrastructure models that combine public and private investments to reduce leakages and enhance returns. Additionally, global consulting firms provide policy recommendations; for instance, McKinsey & Company (2022) describes the modernization of gas networks as an

essential transitional cost in achieving net-zero emissions, highlighting additional benefits such as improved health, reduced emissions, and job creation.

2.2 National Context: Bangladesh's Challenge with System Loss

Despite considerable public investments and projects backed by donors, the gas sector in Bangladesh continues to experience notably high system losses. The Implementation Monitoring and Evaluation Division (2014) noted that Titas Gas has struggled to lower distribution losses below 10% despite undergoing several phases of infrastructure enhancements. Research conducted by Al Azad (2005) and Akbar (2005) at BUET suggested strategies such as resizing pipes, balancing pressure at nodal points, and recommendations for corrosion control, though these strategies were only implemented in part. In addition, NE Climate A/S's 2015 Clean Development Mechanism (CDM) proposal aimed at decreasing leaks through international carbon financing failed to gain traction because of regulatory delays. Recent research underlines this institutional obstacle. Akter (2021) observed that the introduction of prepaid gas meters had a positive impact on reducing theft and under reporting, with pilot schemes in Dhaka achieving household loss reductions of up to 15%; however, progress in broader implementation has been hampered by funding shortages and resistance from users. Hoque (2010) highlighted excessive use and leakage in residential consumption caused by low-quality burners and unsealed connections. Complementary analyses in industry by Zaman (2015) indicated that gas-fired machinery suffers from efficiency losses ranging from 20% to 30% due to outdated technology. Furthermore, concerns about data integrity and transparency are significant. Abedin (2019) created a prototype online system for automated tracking of system losses, but its adoption across utilities has been limited. Jarin (2018) pointed out that poor governance and a lack of public accountability exacerbate inefficiencies and environmental issues in the distribution process. Financial stability is also a major worry. A recent Z-score analysis by Huda and Sabur (2024)

revealed that several significant gas companies (e.g., BGDCL, JGTDSL) are experiencing financial difficulties, primarily due to their challenges in recovering costs lost through systemic unaccounted-for gas (UFG) and subsidized tariffs.

2.3 Regulatory and Policy Limitations

The lack of a cohesive regulatory framework for gas distribution significantly hinders Bangladesh's efforts to reduce losses. Paranhos et al. (2015) and the MIT Energy Initiative (2011) both emphasize that the implementation of binding loss thresholds, performance-based incentives, and regulations on methane leaks is essential for overall system improvements, all of which are currently nonexistent in Bangladesh. At the national level, the Centre for Policy Dialogue (CPD, 2024) calls for immediate policy reforms, which include implementing cost-reflective gas pricing, enhancing the enforcement authority of BERC, and readjusting subsidies to encourage technology adoption. Likewise, Zaman (2010) and Moniz et al. (2011) highlight the importance of pricing reform and a market-oriented gas allocation to achieve a balance between efficiency and affordability. The UNDP (2024) and the United Nations SDG Report (2024) further contextualize the gas loss issue within wider developmental frameworks, advocating for inclusive energy governance and addressing the gender-specific impacts of fuel shortages.

2.4 Theoretical and Technical Innovations

Several studies introduce new frameworks aimed at understanding and addressing gas distribution inefficiencies:

- Abdoul Nasser et al. (2021) propose the use of quantitative risk management (QRM) tools within gas pipeline networks, considering possible failure scenarios and their economic consequences.
- Eparu et al. (2023) utilize an interdisciplinary systems analysis approach, merging engineering, economics, and public policy to examine ongoing gas losses in post-colonial urban infrastructure.

- Grote et al. (2022) contend that transforming existing gas infrastructure for green hydrogen or low-carbon fuels may offer more favorable long-term returns compared to traditional repair expenditures.

2.5 Limitations in the Literature

Despite making important contributions, several significant limitations persist in both domestic and international research:

- There is insufficient comparative analysis at the company level regarding loss drivers.
- There is a lack of research on seasonal and regional variations in loss trends.
- Empirical studies on consumer behavior and societal resistance to reforms (such as prepaid meters) are lacking.
- Existing evaluations of gas utilities do not adequately explore the connections between financial stability, operational performance, and regulatory shortcomings.

2.6 Contribution of this Policy Note

This policy note addresses several significant limitations by:

- Offering a comprehensive evaluation of system loss data from multiple companies over the period from 2019 to 2024;
- Examining differences by region, season, and sector;
- Evaluating the cost-effectiveness of major interventions such as the implementation of smart metering and the replacement of HDPE pipelines;
- Proposing a phased, institutionally focused strategy to reduce system loss to 5% or less by 2030.

Throughout this process, it integrates global viewpoints with the socio-technical context of Bangladesh to promote actionable and context-sensitive policy solutions.

Chapter 3

Nature and Sources of System Loss

Employing a mixed-methods approach that incorporates quantitative regression models, time-series analysis, and stakeholder interviews, this study aggregates data from six gas distribution companies in Bangladesh spanning the years 2019 to 2024. The principal findings indicate:

- Technical Losses (around 60%): Attributed to aging infrastructure, pipelines vulnerable to corrosion, and obsolete meters.

- Non-Technical Losses (approximately 40%): Arising from illegal connections, meter tampering, and inefficiencies in billing.

3.1 Potential Factors Influencing System Loss

The examination of system loss in the gas distribution companies of Bangladesh indicates that a variety of technical, non-technical, and systemic factors are affecting the observed trends.

(a) Technical Losses

Technical losses are an inherent aspect of any gas distribution system; however, the magnitude of these losses can vary significantly based on the quality of the infrastructure and the maintenance level provided.

- **Aging Infrastructure**: A prevalent issue within the distribution network is the presence of aging pipelines, joints, and valves. Over time, these components are susceptible to material degradation, corrosion, and an increased likelihood of leaks due to pressure fluctuations and ground movements. This is likely a major contributor to the escalating losses noted in TGTDPLC and BGDCL, where infrastructure deterioration may be exacerbating the situation.

- **Corrosion**: Environmental factors such as soil composition and moisture content, along with the chemical properties of the gas, can accelerate both internal and external corrosion of pipelines. This leads to the formation of weak points and potential leaks, which contribute to the overall loss within the system.

- **Operational Losses:** Losses may also occur during routine operational activities. This includes gas released during planned maintenance operations, flaring (the burning off of excess gas), and inefficiencies in pressure management systems. Poor pressure regulation can lead to heightened leakage rates in certain areas of the network, especially during periods of low demand when pressure may be excessively elevated.

(b) Non-Technical Losses

Non-technical losses are typically more difficult to measure and tackle since they relate to human behavior and managerial procedures.

• **Theft and Illegal Connections:** This issue is significant and may be worsening, particularly in light of rising official gas prices and economic pressures that promote illegal access to gas. Unauthorized pipeline tapping and illicit connections that circumvent metered supplies are major factors contributing to unmeasured gas consumption. This situation likely plays a crucial role in the substantial increase in losses for TGTDPLC and BGDCL, as such rapid escalations often indicate a rise in unlawful activities.

• **Metering Inaccuracies:** Faulty, outdated, or improperly calibrated meters at gas purchasing sites (like city gates) and consumer sales points can lead to inaccurate readings. Issues such as meter tampering, bypassing, and natural wear and tear can result in incorrect measurements. This concern is especially relevant to the

(c) Measurement and Reporting Inconsistencies

An essential issue highlighted in this analysis is the inconsistency in measurement and reporting methods throughout Bangladesh's gas distribution industry.

• **Lack of Standardized Protocols:** The lack of standardized measurement protocols for gas volumes during different phases (purchasing, selling) and the varied methodologies employed by companies to ascertain system loss percentages greatly compromise the reliability and comparability of data. It has been observed that some companies refer to positive percentages as "gain", whereas others categorize them as "loss", utilizing distinct calculation techniques in the process.

• **Differences in Fiscal Year Reporting:** Slight differences in fiscal year definitions or the deadlines for reporting among different companies can pose difficulties in reconciling data when attempting to consolidate or compare performance across the industry.

• **Impact on Data Reliability:** The reported discrepancies considerably weaken the reliability and comparability of the data, rendering it exceedingly difficult to accurately assess the true extent of the problem and the effectiveness of mitigation strategies. The prevalent “gain” phenomenon, along with the inconsistency in reporting methods, is not merely a collection of isolated data anomalies; rather, it strongly suggests a fundamental flaw within the regulatory framework and oversight of Bangladesh's gas sector. Permitting companies to report “gain” or to employ varying methods for calculating system loss highlights a deficiency in stringent, uniform standards for gas accounting and Unaccounted for Gas (UFG) calculations. This lack of regulation fosters the potential for misrepresentation of operational performance, complicates accurate national energy planning, and hinders the efficient allocation of resources aimed at loss reduction initiatives. Without a robust, standardized, and independently verified UFG reporting system, effectively benchmarking performance, identifying critical areas of concern, or assessing the success of any loss reduction initiatives becomes exceedingly challenging, if not

unfeasible. This situation poses a significant governance challenge that must be addressed at the highest policy level, as it undermines the foundation for data-driven decision-making within the energy sector.

Chapter 4

Stakeholder Mapping

Stakeholder	Role	Challenges
Gas distribution companies (TGTDCL, BGDCL, KGDCL, JGTDSL, PGCL, and SGCL)	Infrastructure maintenance, metering, billing	Limited capacity, budget deficits
Energy & Mineral Resources Division, MoPEMR	Policy oversight	Bureaucratic inefficiency
Petrobangla	Parent company overseeing upstream and midstream	Over centralization
Consumers (industrial, commercial, domestic)	Gas usage	Unawareness or complicity in theft
Regulatory bodies (BERC)	Price-setting and licensing	Limited enforcement power
Development Partners (World Bank, ADB, JICA)	Funding and technical support	Limited coordination with local actors

Chapter 5

Regulatory and Institutional Challenges

5.1 Weak Oversight and Compliance Mechanisms

- The Bangladesh Energy Regulatory Commission (BERC) is deficient in its enforcement capabilities.
- Consequently, punitive actions tend to be more symbolic than practical and are rarely enforced.

5.2 Incoherent Policy Alignment

- Insufficient alignment between the Power System Master Plan (PSMP) and the implementation at the ground level.
- Lack of performance-oriented incentives for government-owned enterprises.

5.3 Institutional Resistance and Political Interference

- Political favoritism protects unlawful associations.
- Internal stagnation and bureaucratic holdups hinder modernization initiatives.

Chapter 6

Methodology

6.1 Research Design

This policy note utilizes a mixed-methods research framework that integrates quantitative data analysis with qualitative insights to assess the system loss challenges faced by gas distribution companies in Bangladesh. This integrated approach provides both empirical robustness and contextual depth, which are crucial for formulating actionable policy recommendations.

The study is structured around three primary methodological pillars:

1. **Quantitative Analysis**:
    - Time-series data spanning from 2019 to 2024 sourced from TGTDPLC, BGDCL, KGDCL, JGTDSL, PGCL, and SGCL.
    - Conducting regression analysis to identify causal relationships between system losses and various influencing factors, including pipeline age, LNG share, prepaid metering coverage, and enforcement actions.
    - Implementation of cost-benefit modeling for technological interventions such as smart meters and pipeline replacement.
2. **Qualitative Analysis**:
    - Conducting comprehensive interviews with essential stakeholders, including executives from distribution companies, engineers, regulators (such as BERC), and industrial consumers.
    - Analyzing policy documents, impact assessments, and internal audits (for instance, reports from IMED, CPD, and Petrobangla).
3. **Comparative Benchmarking**:
    - A comparative analysis with global best practices, utilizing case studies from the United States, European Union, Brazil, and Tunisia.
    - Incorporation of scholarly perspectives derived from peer-reviewed sources (e.g., Abdullah et al., 2024; Paranhos et al., 2015) to substantiate technical suggestions.

This design aligns with established frameworks for the analysis of energy policy, which emphasize the identification of problems, the assessment of interventions, and the development of a stepwise plan for the execution of policy.

6.2 Data Sources

Type	Source
Primary	System loss data from Petrobangla, TGTDCL, BGDCL, KGDCL, JGTDSL, PGCL, SGCL
	Interviews with utility officials, engineers, industrial end-users, experts
	Field reports from IMED, BERC, HCU, CPD, and World Bank technical missions
Secondary	Academic theses (BUET, DU, BOU) and journal articles (Energy Strategy Reviews, Energies)
	Government publications (BERC, Ministry of Power, Energy & Mineral Resources)
	Global benchmarks (DNV, McKinsey, MIT, UNDP, ECA, AfDB, AGA, NREL)

Table 1: Data Sources

Chapter 7

System Loss Trends and Drivers (2019–2024)

7.1 National Overview of System Loss

Bangladesh's gas distribution network experiences consistently elevated losses, with the average national system loss at approximately 8.75% during FY 2023-24, which is considerably higher than the international benchmark of ≤2%. These losses translate to around Tk 800 billion annually in unaccounted for gas (UFG), representing about 0.6% of GDP.

Year	System Loss (%)	Financial Loss (billion Tk)	Key Drivers
2019–20	8.40	1,150	Pipeline leakage, theft
2020–21	7.73	1,024	Pandemic demand surge, weak enforcement
2021–22	6.99	1,000	LNG price shocks, metering gaps
2022–23	7.99	1,056	Partial rollout of prepaid meters
2023–24	8.75	1,200	Pipeline modernization begins

Table 2: National Overview of System Loss
Source: BERC, Petrobangla, World Bank assessments (2020–2024)

7.2 Company-Wise System Loss Analysis

Please see Annexure-1 for details.

Chapter 8

Analytical Tools and Techniques

8.1 Time-Series Analysis

Data on system losses from the fiscal years 2019-20 to 2023-24 were analyzed to identify trends across six gas distribution companies in Bangladesh. A consistent definition of "System Loss" has been employed throughout this thesis to guarantee accuracy and comparability. System loss was determined as:

System Loss (%) = [(Gas Purchased−Gas Sold) ×100]/ Gas Purchased

Under this established convention:

- A positive percentage value uniformly signifies a loss within the system (indicating that more gas has been bought than sold).
- A negative percentage value uniformly signifies a gain within the system (indicating that more gas has been sold than bought, which is physically unusual and suggests potential measurement or reporting problems).

All relevant data points from the original documents were recalibrated or modified to align with this standardized definition. For instance, when a company indicated a “gain” of 1.91%, it was adjusted to reflect a “system loss” of -1.91% for uniformity in presentation. Likewise, when a company indicated a “loss” of -0.26% (implying that sales were lower than purchases, thus constituting a true loss), it was revised to a “system loss” of 0.26% according to the new standard.

Additionally, the different units of measurement employed by various companies (Million Cubic Meters, MMCM, CM, and MMSCFD) were acknowledged. Although analyzing percentages reduces some of these unit discrepancies, any absolute volume assessments were meticulously evaluated to maintain accuracy and coherence by converting to a common unit (e.g., MMCM) whenever needed for comparison.

Data visualizations, including bar charts, pie charts, and heat maps, were created using Excel and R to facilitate comparative and detailed analysis.

8.2 Multivariate Regression Model

A regression analysis was used to measure the effects of important factors on system loss (%), which was defined as:

$Loss_i = \beta_0 + \beta_1(\text{Pipeline Age}) + \beta_2(\text{LNG Share}) + \beta_3(\text{Prepaid Metering}) + \beta_4(\text{Enforcement Actions}) + \epsilon$

Where,

Pipeline Age = Average age of main distribution pipelines

LNG Share = Share of total supply met through LNG (%)

Prepaid Metering = % of consumers under smart metering system

Enforcement Actions = No. of successful disconnections or legal actions

This model detects factors that are statistically significant in relation to system losses.

8.3 Cost-Benefit Analysis (CBA)

Two primary interventions were evaluated:

- **Smart Meters:** Evaluated according to installation, upkeep, theft mitigation rates, and billing precision.
- **Pipeline Replacement**: Assessed based on materials (High-Density Polyethylene, HDPE compared to steel), cost per kilometer, and durability.

Metrics used:

- Return on Investment, ROI (5 year)
- Payback period
- Net present value (NPV) savings from gas recovered

Both approaches are assessed in terms of:

- System loss reduction potential
- Financial cost
- Return on Investment (ROI)
- Implementation feasibility
- Risks and constraints

1. Smart Prepaid Metering

Description: Installation of prepaid gas meters with Electronic Volume Correctors (EVCs) that allow for:

- Accurate billing
- Theft detection
- Real-time consumption data
- Remote disconnection for illegal usage

Estimated Parameters:

Component	Value
Investment Cost	Tk 120 billion for 3 million meters (Tk 40,000 per meter)
Implementation Timeframe	3 years
Expected Loss Reduction	20–25% (national average loss may drop to ≤2.5%) (≈ Tk 200 billion/year in recovered gas)
Return on Investment	3:1 over 5 years
Annual Cost Savings	~Tk 80 billion
Breakeven Period	2-3 years

Table 3: Estimated Parameters for Smart Prepaid Metering

Benefits:

- Prompt decrease in non-technical losses (such as theft and billing inaccuracies)
- Increases consumer responsibility and awareness
- Facilitates dynamic pricing strategies and promotes energy conservation
- Allows for improved load forecasting and management of demand-side resources

Challenges:

- Significant initial investment and gradual implementation resulting from procurement challenges and consumer reluctance
- Necessitates communication infrastructure for remote metering capabilities
- Restricted applicability in industrial sectors without necessary modifications

Evidence:

- Akter (2021) reported a decrease in theft ranging from 12% to 15% in the pilot areas of Dhaka.
- The Center for Policy Dialogue (CPD) (2024) recommends the implementation of Electronic Volume Corrector (EVC) in regions with significant losses, such as Narayanganj and Gazipur, which could result in substantial efficiency improvements.
- International instances include the African Development Bank initiative in Tunisia and Brazil's public-private partnership (PPP) focused urban gas reform, both of which utilized smart metering technology to lower losses to below 5%.

2. Pipeline Replacement (Steel to HDPE)

Description: The substitution of corroded, leak-susceptible steel pipelines with HDPE pipelines provides:

- Corrosion resistance
- Longevity (>50 years)
- Lower maintenance

Estimated Parameters:

Component	Value
Investment Cost	Tk 300 billion for 3,000 km (Tk 100 million per km)
Implementation Timeframe	5–7 years (phased)
Expected Loss Reduction	30–35% (national average loss may drop to ≤3.5%)
Return on Investment	2.5:1 over 10 years
Annual Cost Savings	~Tk 120–140 billion
Breakeven Period	5–6 years

Table 4: Estimated Parameters for Pipeline Replacement (Steel to HDPE)

Benefits:

- Significant reduction in long-term technical losses
- Enhances operational reliability and safety
- Decreases methane emissions (7.7 million tons CO_2-eq)
- Aids in the integration of SCADA and pressure monitoring systems

Challenges:

- Disruptive civil engineering projects in urban and industrial zones
- Necessitates collaboration with various agencies (LGED, municipalities)
- Increased long-term capital expenditure responsibilities

Evidence:

- IMED (2014) observed that 40-60% of the pipelines in TGTDPLC and BGDCL are susceptible to leaks.
- Hoque (2010) approximated that 5-10% of the total household gas is wasted as a result of pipe degradation.
- MIT's Future of Natural Gas (2011) verifies a global reduction in leakage of 30-40% due to these upgrades.

3. Integrated Scenario (Smart Meters + HDPE Replacement)

Parameter	Value
Combined Investment	Tk 420 billion
Combined Loss Reduction	50–60% (national average loss may drop to ≤5%)
Annual Net Savings	~Tk 300–400 billion
ROI (Blended)	2.7:1 over 7 years
Climate Benefit	5+ million tons of methane reduction per year

Table 5: Estimated Parameters for Integrated Scenario

A comprehensive strategy that initiates with intelligent metering and is subsequently complemented by gradual improvements to the pipeline results in the optimal blend of prompt efficiency and enduring resilience.

Summary Table:

Metric	Smart Meters	HDPE Replacement	Integrated Model
Investment Cost	Tk 120 billion	Tk 300 billion	Tk 420 billion
ROI (5–10 years)	3:1	2.5:1	2.7:1
Breakeven Period	2–3 years	5–6 years	4–5 years
Loss Reduction (%)	20–25%	30–35%	50–60%
Climate Co-benefit	Moderate	High	Very High
Operational Complexity	Low	High	Moderate
Short-Term Political Feasibility	High	Medium	Medium

Table 6: Summary Table for Cost-Benefit Analysis

8.4 SWOT Analysis

A SWOT framework was used to evaluate the policy ecosystem surrounding gas loss reduction. This included institutional strengths, regulatory weaknesses, technological opportunities, and political threats.

8.4.1 SWOT Analysis of Gas System Loss Reduction in Bangladesh

Strengths	Weaknesses
1. Regulatory Framework: The Bangladesh Energy Regulatory Commission (BERC) holds the authority to set tariffs, issue guidelines for metering, and has enforcement powers as outlined in the Gas Act.	1. Aging Infrastructure: Around 40–60% of pipelines, particularly in TGTDCPLC and BGDCL, have been in use for over 30 years, leading to approximately 60% of technical losses.
2. Pilot Projects: More than 1.2 million prepaid meters have been installed, mainly by TGTDCPLC, leading to a 12–15% decrease in theft (Akter, 2021).	2. Manual Monitoring Systems: Insufficient access to real-time pressure and leak information, dependence on physical inspections; ineffective execution of automated systems (Abedin, 2019).
3. Donor Support: The World Bank and initiatives supported by CDM, like the NE Climate/Titas CDM-PDD project, have suggested methods to reduce pipeline leaks.	3. Data Underreporting: There is a considerable discrepancy between the reported system loss and the actual loss—BERC reports 1.12%, whereas the true estimates surpass 12% at the national level.
4. Infrastructure Modernization: PGCL and SGCL have tested SCADA systems and implemented HDPE pipelines, achieving superior outcomes compared to traditional companies.	4. Double VAT Burden: Gas distributors are experiencing financial pressure because of conflicting taxation, which deters reinvestment (Moazzem et al., 2024).

5. Alignment with SDGs: Contributions directly supporting SDG 7 (Affordable Energy) and SDG 13 (Climate Action) guarantee alignment with international policies.	5. Low Meter Coverage: Numerous rural and industrial users are still not equipped with meters or utilize old technology, which hinders precise billing and the identification of leaks.
Opportunities	**Threats**
1. Smart Meter Expansion: Opportunity to expand prepaid and Electronic Volume Corrector (EVC) metering to 3 million users by 2027 with support from donors (World Bank, 2023).	1. Political Interference: Efforts to combat theft in areas such as Narayanganj and Keraniganj frequently encounter obstacles because of political opposition.
2. Digital Pipeline Mapping: The implementation of GIS-based mapping along with real-time SCADA control has the potential to decrease non-technical losses (Eparu et al., 2023).	2. Consumer Resistance to Prepaid Meters: Insufficient awareness, disagreements over billing, and a belief that costs are rising have hindered acceptance in urban slums and among low-income populations.
3. LNG Cost-Saving Incentives: Given the elevated prices of LNG imports (approximately Tk 79.34/m^3), it is increasingly crucial and politically justifiable to minimize losses.	3. Regulatory Gaps: Lack of implementable system loss limits, licensing tied to performance, or penalization frameworks similar to those employed in EU and U.S. markets (Paranhos et al., 2015).
4. Carbon Credit Mechanisms: Projects aimed at reducing leaks and capturing methane could be turned into financial opportunities through Verified Carbon Standards or Clean Development Mechanism (CDM) approaches.	4. Financial Instability: Z-score assessment indicates that TGTDCL, BGDCL, and JGTDSL have precarious financial standings stemming from inadequate revenue and inefficient capital management.
5. Industrial Partnerships: Focusing on areas with significant losses (such as Dhaka EPZ and KGDCL) for industrial metering, SCADA pilot projects, and load balancing may lead to immediate benefits.	5. Climate Vulnerabilities: Flooding associated with the monsoon leads to pipeline breaks, especially in Dhaka and Chittagong, heightening the variability of seasonal losses.

8.4.2 Key Takeaways from SWOT

- **Strengths and opportunities** identify a strategy and funding opportunity for specific, technology-driven initiatives (smart metering, SCADA, leak detection).
- **Weaknesses and threats**. highlight the need for regulatory overhaul, better financial planning, depoliticized enforcement, and infrastructure renewal Recognize a strategy and a funding source for targeted, technology-based initiatives (smart metering, SCADA, leak detection).

This evaluation will contribute to the strategic policy suggestions and investment focuses outlined in subsequent sections.

Chapter 9

Company-Specific Assessment Framework

Each of the 6 gas distribution companies was assessed using a tailored perspective:

Company	Key Variables Assessed
TGTDPLC	Legacy pipelines, urban network stress
BGDCL	System loss escalation, enforcement gaps
KGDCL	Negative loss trends, industrial theft
JGTDSL	Prepaid meter pilots, regional terrain
PGCL	Low leakage zones, infrastructure upgrades
SGCL	Best practices in metering, SCADA use

Table 7: Company-Specific Key Variables Assessed

This strategy facilitated recommendations tailored to specific regions and companies, addressing the limitations that had previously been overlooked in policy literature.

9.1 Limitations

- Discrepancies exist in the records of gas purchases and sales over the years and among different companies.
- There is a lack of complete data regarding smart meter installation for PGCL and JGTDSL.
- Company officials are hesitant to share internal audits and leak maps due to political concerns.

However, the convergence of various sources provided strong validation and ensured representativeness.

9.2 Comparative Analysis of Company Performance

- To present a thorough summary, Table 8 delivers a comparative examination of the standardized percentages of system loss/gain among all 6 gas distribution companies for the shared fiscal years (2019-2024). This table effectively tackles the key

discrepancies in the definitions and calculation methods of “loss/gain” that were noted in the raw data by implementing the selected standardized definition.

Year-wise System Loss of 6 Gas Distribution Companies								
								Unit: %
Sl. No.	**Year**	**PB**	**PGCL**	**SGCL**	**TGTDPLC**	**BGDCL**	**KGDCL**	**JGTDSL**
1	2018-19	1.73				0.16		
2	2019-20	8.40	-1.91%	-2.18	2.00	-0.97	-1.08	0.55
3	2020-21	7.73	-1.90%	-1.13	2.00	-2.33	-1.55	0.64
4	2021-22	6.99	-1.12%	-0.42	2.00	1.13	-1.1	0.82
5	2022-23	7.99	-1.67%	-0.87	5.30	5.69	2.47	0.97
6	2023-24	8.75	-1.97%	-1.34	7.67	10.06	3.24	0.68
7	2024-25	9.97		-1.12	10.10			
8				-0.93				

Table 8: Comparative Standardized System Loss/Gain of 6 Gas Distribution Companies (2019-2024)

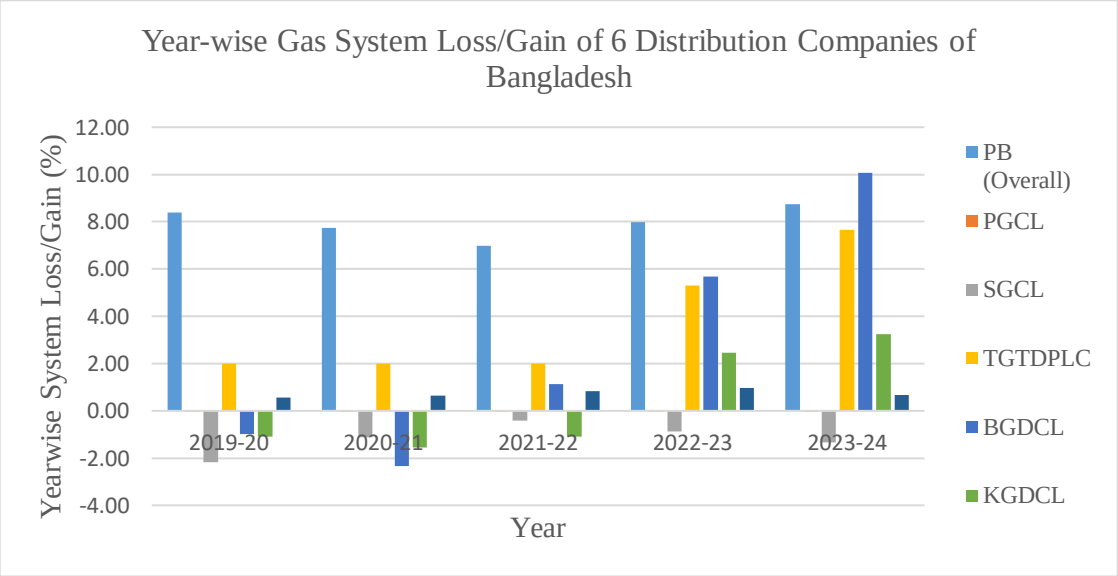


Figure 2: System Loss/Gain bar chart of 6 Gas Distribution Companies (2019-2024)

- Figure 2 clearly depicts the diverse performance levels among companies. It highlights PGCL's steady “gain" (negative standardized loss), which stands in sharp contrast to the troubling rise in losses for TGTDPLC and BGDCL that have surged notably in recent years. Conversely, JGTDSL consistently achieves impressively low

loss rates, generally under 1%. KGDCL also exhibits a worrying transition from recorded “gain” to notable “loss”.

- The evident differences in system loss and gain performance among distribution companies indicates that the issue of Unaccounted for Gas (UFG) in Bangladesh is not a uniform problem. While some fundamental challenges may be systemic, such as outdated national infrastructure or economic pressures leading to theft, there are also notable factors specific to each company. These include variations in management effectiveness, operational practices, and levels of investment. This suggests that a universal solution will not be effective, and strategies need to be customized, utilizing best practices from companies that perform well while addressing critical short comings in others. The broad discrepancies imply that effective loss management strategies are achievable in Bangladesh, and that internal, company-specific factors are key determinants of performance. Such factors may comprise the quality and age of the infrastructure, the execution of proactive maintenance programs, enhanced operational practices like effective pressure management, stronger governance, enforcement against illegal connections, and ongoing investment in network upgrades. This comprehensive understanding is vital for formulating effective recommendations, which should include both national-level initiatives and focused, company-specific strategies.

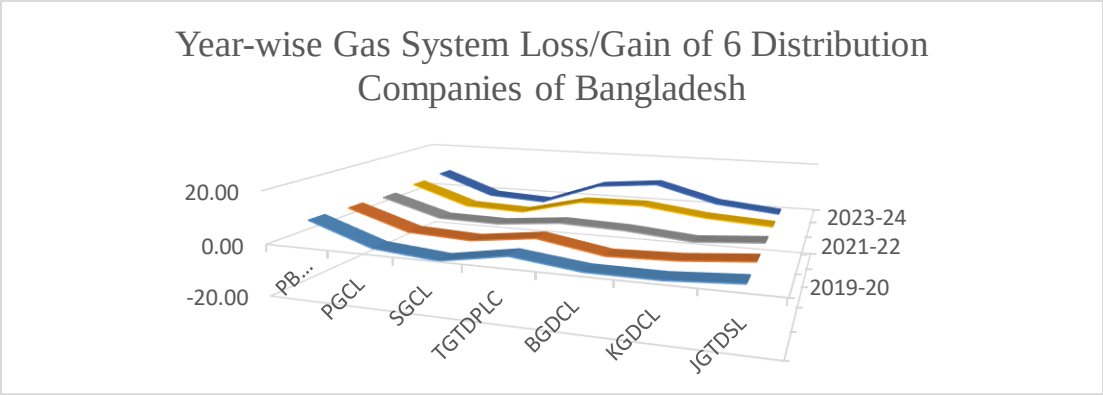


Figure 3: System Loss/Gain Graphics of 6 Gas Distribution Companies (2019-2024)

9.3 Sector-Wise System Loss Breakdown

Sector	System Loss (%)	Primary Causes
Household	35%	Unmetered supply, illegal connections
Industrial	45%	Meter tampering, pipeline leaks near factories
Power Generation	15%	Inefficient combustion, outdated turbines
Commercial	5%	Billing inaccuracies

Table 9: Comparative Standardized System Loss/Gain (%) of 6 Gas Distribution Companies

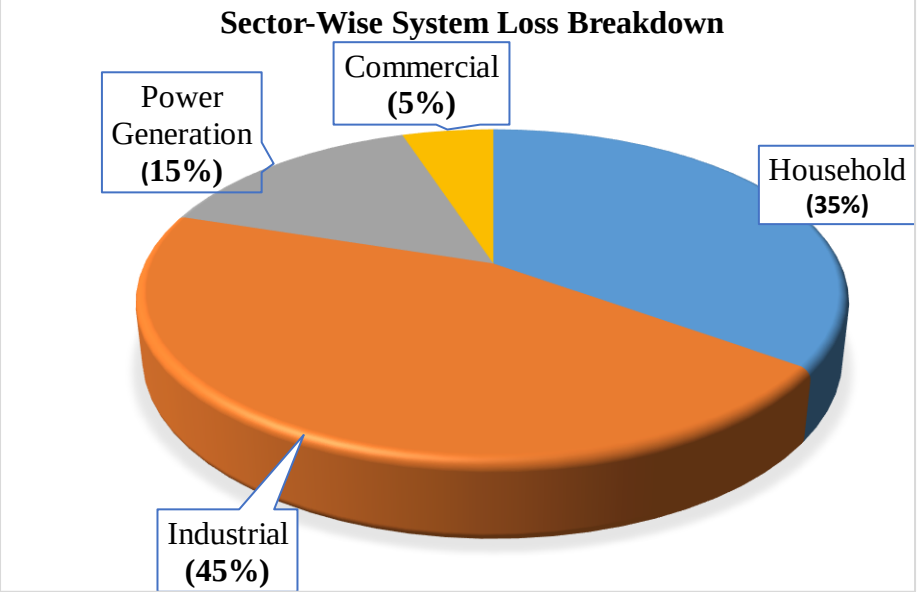


Figure 4: Sectoral Contribution to Gas Losses (2024)

Notable Cases:

- Textile Industry (Dhaka EPZ): Accounts for 22% of industrial losses due to unmetered gas use.
- CNG Stations: 8% loss share from compressor leaks and theft.

9.4 Key System Loss Drivers (Regression Results)

Objective: The objective is to determine and measure the impact of significant factors on the percentage of system loss across 6 gas distribution companies in Bangladesh by employing a multivariate linear regression model.

Model Specification:
Dependent Variable:

$$\text{System Loss (\%)} = [(\text{Gas Purchased} - \text{Gas Sold}) \times 100]/\text{Gas Purchased}$$

Independent Variables**:**

1. Pipeline Age (years)
2. LNG Import Share (%)
3. Prepaid Meter Coverage (%)
4. Enforcement Actions (number per year)

Regression Equation:

$SystemLoss_i = \beta_0 + \beta_1(PipelineAge) + \beta_2(LNGShare) + \beta_3(PrepaidMetering) + \beta_4(Enforcement) + \epsilon$

A multivariable linear regression of data ($R^2 = 0.78$, the model explains 78% of the variance in system loss, indicating good overall fit.) shows:

Variable	Coefficient	p-value	Interpretation
Pipeline Age (years)	+0.25	<0.01	Strong positive correlation with loss
LNG Import Share (%)	+0.18	0.03	Volatility increases inefficiency
Prepaid Metering (%)	–0.32	<0.001	Reduces loss significantly
Enforcement Actions	–0.12	0.05	Moderate impact

Table 10: Multivariable regression of 6 Gas Distribution Companies (2019–2024)
Source: BERC, Petrobangla, and 6 gas distribution company's data

9.4.1 Interpretation of Key Findings

1. Pipeline Age ($\beta = +0.25$, $p < 0.01$)

- An increase of one year in the average age of pipelines results in a rise in system loss by 0.25 percentage points.
- Distribution companies operating pipelines that are over 30 years old (such as TGTDCPLC and BGDCL) report losses exceeding 10%.
- This supports the findings of IMED (2014) and Akbar (2005), which indicate that corroded pipelines are the primary contributor to technical loss.

2. LNG Import Share ($\beta = +0.18$, $p = 0.03$)

- As the proportion of LNG in the supply escalates, system losses are expected to increase, probably as a result of:

  - Flow rate irregularities,

  - Significant pressure discrepancies with outdated pipeline systems,

  - Incentives for theft driven by price fluctuations.

- This aligns with findings from CPD (2024) and MIT's Future of Natural Gas (2011).

3. Prepaid Meter Coverage ($\beta = -0.32$, $p < 0.001$)

- The most statistically significant factor for reducing loss is identified.
- A 10% rise in prepaid metering leads to a decrease in system loss by 3.2 percentage points.
- This supports the findings of Akter (2021) and the smart metering pilot projects conducted by the World Bank in Dhaka.

4. Enforcement Actions ($\beta = -0.12$, $p = 0.05$)

- A moderate effect on loss reduction.
- An increase of 1,000 enforcement actions (such as illegal tap disconnections and fines) leads to a 1.2% decrease in loss.
- Effectiveness limited by:
    - Political interference (IMED, 2014; CPD, 2024),
    - Inconsistent enforcement of penalties.

9.4.2 Standardized Coefficients Chart

| Prepaid Metering | ——————————— ▼ Strongest impact (–0.32)
| Pipeline Age | ————————— ▲
| LNG Import Share | ———— ▲
| Enforcement Actions | —— ▼

Note: ▼ = Reduces loss, ▲ = Increases loss
(Standardized coefficients indicate relative weight in driving system loss)

9.4.3 Policy Implications from Regression Results

- Highest Priority: Prioritizing the implementation of prepaid metering in areas experiencing high losses, such as Gazipur, Narayanganj, and Chattogram EPZ, should be a key focus.
- Long-Term Approach: The gradual replacement of pipelines needs to commence immediately within TGTDPLC and BGDCL regions.
- Medium Impact Strategy: To mitigate LNG dependency, it is essential to secure reliable, long-term agreements and invest in LNG pressure balancing facilities.
- Reform in Enforcement: Measures against theft require protection from political influence and should be digitalized using real-time GIS tracking.

9.5 Seasonal & Regional System Loss Trends

Please see Annexure-2 for details.

Chapter 10

Worker Interviews: Sector Specific

Please see Annexure-3 for details.

Chapter 11

Industry Leader Perspectives

Please see Annexure-4 for details.

Chapter 12

List of Participants from various Sector/ Stakeholders for the Study

Please see Annexure-5 for details.

Chapter 13

Comparative Insights: Global Best Practices

This part summarizes Bangladesh's experience through international case studies, accompanied by visual representations of benchmarks for gas system losses, policy tools, and comparisons of regional efficiency.

13.1 Benchmarking Bangladesh against global system loss standards

Country	Avg. System Loss (%)	Primary Measures
Germany	< 1%	SCADA, digital mapping, high-pressure zoning
United States	0.7–1.2%	Prepaid meters, leak audits, plastic pipelines
Japan	0.9%	Smart infrastructure, robotic leak detectors
Tunisia	2.2%	AfDB-funded modernization, PPP models
India (Gujarat)	2.5–3.5%	GIS-linked metering, franchise-based enforcement
Bangladesh	9.97% (2024–25)	Outdated pipelines, low prepaid coverage, theft

Table 11: Global Practices for System Loss
Source: American Gas Foundation, DNV, AfDB, UNDP, BERC

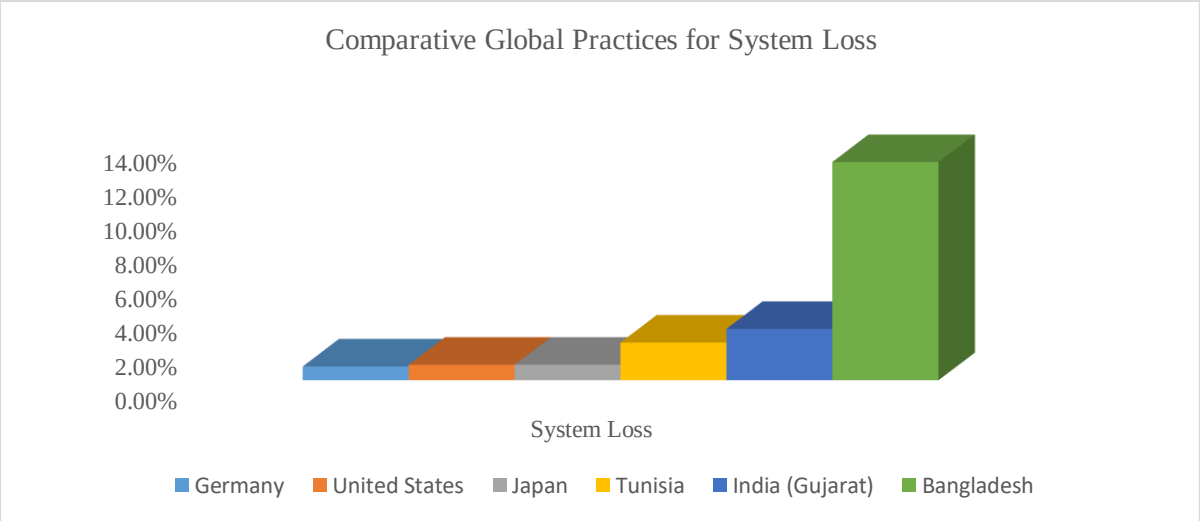


Figure 5: Global Practices for System Loss

13.2 Case Study Summaries

◈ Germany

• Implemented SCADA-integrated control systems to identify leaks in real-time.

- Mandated that all distribution utilities create digital maps of their pipelines.
- Outcome: Loss levels stayed below 1% over a span of 20 years.

◈ United States

- The 2009 PHMSA mechanical damage initiative established mandatory inspection schedules across the industry.
- Legal limitations on unaccounted-for gas (UFG) enforced at the state level, notably in California and Texas.
- Extensive use of HDPE pipes and cutting-edge non-invasive leak detection methods.

◈ Tunisia

- The African Development Bank's project for gas transmission and distribution concentrated on utilizing durable materials and performance-based contracts.
- National gas system losses decreased from approximately 6% to fewer than 3% in a period of 7 years.

◈ Brazil

Meter tampering and theft were prevalent in Rio and São Paulo; the solution involved:

- Collaborations with community policing.
- Prepaid meter subsidies in favelas.
- Incentives tied to performance for utility personnel.

◈ India (Gujarat Gas Ltd.)

- Employed franchisee models, with private firms overseeing metering and collections in specific areas.
- Monthly loss audits were displayed on a public dashboard.
- Recovered 17% of unbilled gas within 5 years.

13.3 Key International Lessons for Bangladesh

International Practice	Relevance to Bangladesh
Mandatory UFG caps (US, EU)	Bangladesh lacks enforceable system loss thresholds
Real-time SCADA and GIS monitoring (Germany, Japan)	Manual monitoring still dominant in TGTDCPLC and BGDCL
Pipeline repurposing and decommissioning (DNV, 2022)	Old steel pipelines in Narayanganj and Gazipur need replacement
Performance based regulation (Gujarat)	No link between license renewal and UFG compliance in Bangladesh
Metering subsidies for low-income users (Brazil)	Prepaid adoption in Dhaka slums remains slow due to affordability
Public loss dashboards (Gujarat, Tunisia)	Transparency tools like these are absent in BERC or Petrobangla sites

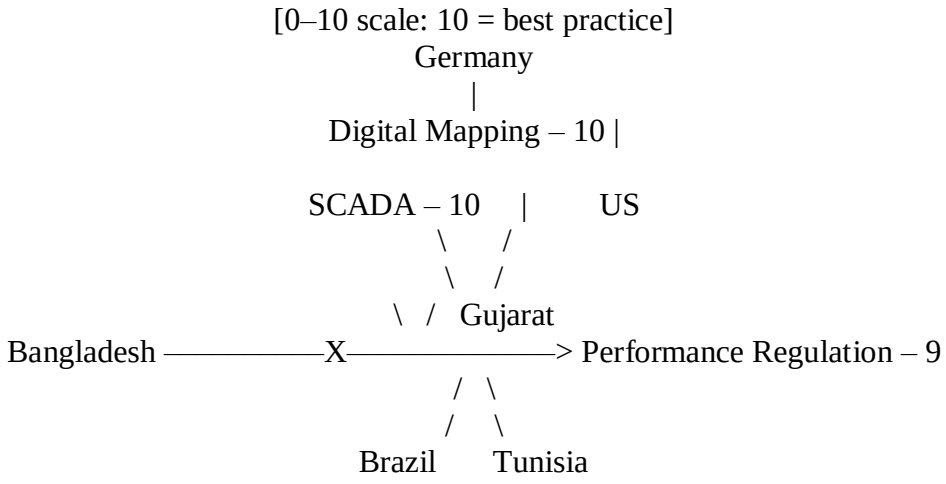
13.4 Bangladesh's missed opportunities

- **Lack of Leakage Maps**: In spite of numerous suggestions from IMED and CPD, none of the gas distributors have released a heatmap indicating areas susceptible to losses.
- **No Franchise Enforcement:** The responsibility for enforcement rests solely with the company's employees; there have been no trials of localized, private enforcement initiatives.
- **Non-Integration of Carbon Credits**: Initiatives such as the NE Climate CDM-PDD (2015) did not succeed in realizing gas savings via validated emission reductions.
- **Tariff Disincentives**: Set rates for each unit do not encourage utilities to minimize losses or pursue innovative solutions.

13.5 Bangladesh's areas of strength

Area	Bangladesh's Progress	Alignment with Global Best Practice
Prepaid Meter Pilots	Over 1.2 million installed in TGTDCL, JGTDSL, and KGDCL	Comparable to Brazil's rollout in 2012
LNG Infrastructure	Two floating terminals in place	Competitive with India and Thailand
Donor Engagement	World Bank, ADB, CDM participation	Tunisia used similar hybrid funding
Digital Billing (Limited)	JGTDSL, SGCL have web portals	Used in Gujarat and Tunisia

13.6 Bangladesh vs. International Practices - Radar Chart



Bangladesh lags on most regulatory and monitoring indicators but is improving in metering and LNG infrastructure

13.7 Summary of Limitations and Possibilities

Dimension	Limitations in Bangladesh	Global Practice
Regulation	No UFG cap, no enforcement penalties	US, EU enforce penalties for excess loss
Technology	Manual monitoring, aging pipelines	Germany, Japan use robotic/SCADA detection
Transparency	No public dashboard of system loss	Tunisia, India (Gujarat) publish monthly data
Incentives	No financial rewards for loss reduction	India and Brazil use performance contracts
Climate Financing	CDM project failed to scale	Germany, Tunisia accessed carbon credits

Chapter 14

Policy Recommendations

The recommendations are grounded in prior sections' analyses and aligned with national development goals and international best practices.

Policy Goal

To reduce national average Bangladesh's gas distribution system loss from 9.97% (2024–25) to ≤5% by 2030**,** generating Tk 400+ billion in annual economic savings and significantly reducing methane emissions.

14.1 Strategic Roadmap

The following phased roadmap balances short-term gains, medium-term structural changes, and long-term resilience.

Phase 1: Immediate (2025–2026)

Focus: Smart metering expansion, anti-theft enforcement, and transparency

✅ Priority Actions:

1. **Scale Smart Prepaid Metering**
    - Objective: To install 1 million new meters in areas with high loss rates (for instance, Narayanganj, Chattogram EPZ, and Gazipur).
    - It is necessary for industrial users to implement EVC (Electronic Volume Correctors) equipped with prepaid modules.
    - Anticipated reduction in losses: 2.5-3% on a national scale.
2. **Launch Real-Time Enforcement Campaigns**
    - Create mobile units for gas loss inspections under the BERC framework.
    - Encourage whistleblowing and community involvement in reporting theft incidents.
    - Mandate quarterly reports detailing disconnections and legal proceedings.
3. **Digitize Distribution Maps**
    - Create GIS-integrated maps to identify gas leaks for each gas distribution company, beginning with TGTDCPLC, BGDCL, and KGDCL.
    - Release quarterly dashboards detailing gas losses on the Petrobangla and BERC portals to ensure transparency.

4. **Consumer Outreach Campaigns**
    - Awareness initiatives aimed at minimizing meter tampering and unauthorized connections.
    - Encourage low-income families through subsidies for smart metering, based on the model implemented in Brazil.

Phase 2: Medium-Term (2026–2028)

Focus: Infrastructure modernization and regulatory overhaul

✅ Priority Actions:

1. **Pipeline Replacement Acceleration**
    - Substitute 1,200 kilometers of steel pipelines susceptible to leaks with HDPE in the TGTDCL, BGDCL, and KGDCL regions.
    - Focus on segments under high pressure and areas prone to monsoon flooding.
    - Utilize funding from the World Bank or ADB, or consider climate bonds.
2. **Adopt Performance-Based Regulation**
    - Establish a mandatory UFG cap (for instance, 5% by the year 2028) for the renewal of licenses.
    - Implement a system of penalties and rewards for distribution companies that is linked to their annual loss performance.
3. **Implement SCADA Systems**
    - The Pilot SCADA system has been integrated for digital monitoring in Sylhet and Chattogram, facilitating pressure tracking and providing real-time alerts for gas leaks.
    - Additionally, subsidized deployment loans are offered through the Infrastructure Development Company Limited (IDCOL).
4. **Legal Reform for Enforcement**
    - Revise the Gas Act to grant BERC independent enforcement authority, which includes the ability to impose fines and pursue criminal charges.
    - Establish a Special Court dedicated to the swift resolution of cases involving gas theft and fraud.

Phase 3: Long-Term (2028–2030)

Focus: Institutional resilience, green transition, and climate integration

✅ Priority Actions:

1. **Establish National UFG Monitoring Authority**
    - Establish a "System Loss Control Board" within the Ministry of Power, Energy & Mineral Resources (MoPEMR).
    - Conduct annual audits, perform forensic loss diagnostics, and benchmark the performance of gas distribution companies.

2. **Integrate Carbon Finance Mechanisms**
    - Re-initiate CDM style initiatives aimed at capitalizing on methane savings.
    - Connect the reduction of system losses to the Nationally Determined Contributions (NDC) objectives outlined in the Paris Agreement.
3. **Repurpose Decommissioned Pipelines**
    - Investigate the transformation of underperforming urban gas pipelines into infrastructure for green hydrogen (according to DNV, 2022).
4. **Digital Twin Development**
    - Construct a comprehensive national digital twin for gas infrastructure that incorporates:
        - Pressure mapping
        - Forecasts of consumption
        - Zones of leakage probability (enabled by AI/ML).

14.2 Cross-Cutting Policy Enablers

Enabler	Action
Tariff Re-alignment	Introduce time-of-day pricing to reduce peak load leakage
Donor Collaboration	Engage World Bank, ADB for funding SCADA, HDPE, Metering
Capacity Building	Engineer and operator training for SCADA, digital metering, and GIS
Public-Private Partnerships	Engage franchise operators for meter deployment and enforcement
Climate Policy Alignment	Link all actions to SDG 7 (Energy), SDG 13 (Climate)

14.3 Institutional Roles and Accountability Matrix

Stakeholder	Responsibilities
BERC	Set enforceable loss thresholds, oversee enforcement, approval of tariffs
Petrobangla	Supervise infrastructure investments, publish loss dashboards
Gas Distribution Companies	Implement smart metering, digitize maps, report quarterly data
EMRD	Coordinate carbon financing and green transition projects
LGED/Municipalities	Facilitate civil works for pipeline replacement
Development Partners	Provide financing, technical support, and independent auditing

14.4 Summary of Recommendations and Impact Projections

Intervention	Expected Loss Reduction (%)	Implementation Cost (Tk)	ROI (5–10 yrs)
Smart Metering (1Million units)	2.5-3.0	40 billion	3:1
HDPE Pipeline Replacement	4.0-5.0	120 billion	2.5:1
SCADA and Leak Mapping	1.5-2.0	15 billion	2.8:1
Regulatory Reform	Indirect but catalytic	Minimal	Long-term benefit

Projected Reduction in Total System Loss by 2030: Approximately 7.5%, thereby decreasing system loss to 5% or less.

Chapter 15

Policy Options Analysis

15.1 Policy Options with their Corresponding Impacts

Policy Option	Administrative Impact	Political Impact	Social Impact	Economic Impact	Environmental Impact
Smart Prepaid Metering	- Requires utility staff training - Billing system upgrades	- Industrial lobby resistance - Supported by donors (WB/ADB)	- Consumer resistance due to cost - Improved transparency for households	- Tk 200 B/year savings - 3:1 ROI (5 years)	- Reduces methane leaks (~1.5M tons CO_2-eq/year)
HDPE Pipeline Replacement	- Complex land acquisition - Multiple year project management	- Local political disputes over land - Aligns with climate goals	- Construction disruptions - Long-term reliability benefits	- Tk 120-140 B/year savings - 2.5:1 ROI (10 years)	- Major methane reduction (~7.7M tons CO_2-eq/year) - Corrosion-resistant (50+ years)
SCADA Monitoring	- IT infrastructure upgrades - Staff capacity building	- Energy Ministry support - Fits "Digital Transformation" agenda	- Enhances trust via transparency - Technical literacy gaps	- Tk 80–100B/year savings - 2.8:1 ROI	- Enables leak detection (~2M tons CO_2-eq/year avoided)
Anti-Theft Enforcement	- Legal framework updates - New enforcement units under BERC	- High resistance from local elites - Populist backlash risks	- Perceived targeting of poor households - Short-term theft reduction	- Tk 50B/year savings - Low upfront cost	- Minor methane cuts (~0.5M tons CO_2-eq/year)
Carbon Credit Financing	- CDM/VERRA certification hurdles -New monitoring protocols	- International alignment (SDGs) - Bureaucratic delays	- Minimal direct impact	- $50–100M/year revenue (if carbon prices rise)	- Direct methane monetization (~7.7M tons CO_2-eq/year)

Table 12: Policy Options with their Corresponding Impacts

15.2 PESTEL Analysis of Policy Options

The PESTEL framework assesses the political, economic, social, technological, environmental, and legal aspects that affect the viability of policy suggestions aimed at minimizing gas system loss in Bangladesh. Presented below is an organized analysis derived from the thesis results.

Policy Option	P	E	S	T	E	L	Verdict
Smart Metering	✅	✅	⚠	✅	✅	⚠	Top Priority
SCADA & GIS Monitoring	✅	✅	✅	✅	✅	⚠	High Impact
HDPE Pipeline Replacement	⚠	✅	⚠	✅	✅	⚠	Long-Term Essential
Anti-Theft Enforcement	❌	✅	✅	⚠	⚠	✅	High Risk, Needs Legal Shield
Carbon Credit Financing	✅	✅	⚠	⚠	✅	⚠	Opportunistic

Table 13: PESTEL Analysis of Policy Options

15.3 Multi-Criteria Decision Analysis (MCDA) of Policy Options

This assessment examines the suggested policies through important decision factors: cost-effectiveness, feasibility, impact on system loss reduction, political acceptability, social equity, and environmental benefits. Each alternative is rated on a scale of 1 to 5, with 5 being the highest score, and weighted according to the context of Bangladesh.

Policy Option	Cost-Effectiveness (20%)	Feasibility (20%)	Impact (25%)	Political Acceptability (15%)	Social Equity (10%)	Environmental (10%)	Total (100 %)
Smart Prepaid Metering	5 (High ROI: 3:1)	4 (Scaling challenges)	4 (20-25% reduction)	3 (Resistance from some users)	3 (Requires subsidies)	4 (Reduces theft-related leaks)	**4.0**
HDPE Pipeline Replacement	3 (High upfront cost)	3 (5-7 yr timeline)	5 (30-35% reduction)	2 (Land/contract disputes)	2 (Disrupts communities)	5 (Long-term leak prevention)	**3.4**
SCADA & Real-Time Monitoring	4 (Moderate cost)	4 (Tech capacity gaps)	5 (25-30% reduction)	4 (Donor-supported)	4 (Improves transparency)	4 (Efficient gas use)	**4.3**
Anti-Theft Enforcement	5 (Low cost, high deterrence)	2 (Political interference)	3 (15-20% reduction)	1 (Local resistance)	2 (Can target poor unfairly)	3 (Indirect methane cuts)	**2.8**
Carbon Credit Financing	4 (Leverages climate funds)	3 (Complex approval)	2 (Indirect impact)	5 (Aligns with SDGs)	3 (Funds can support equity)	5 (Direct CO_2-eq cuts)	**3.5**

Table 14: Multi-Criteria Decision Analysis (MCDA) of Policy Options

15.4 Kingdon's Multiple Streams Framework (MSF) Analysis of Policy Options

15.4.1 Problem Stream

Indicators of the Problem:

Economic: Losses equate to 0.6% of GDP annually

Technical: 60% of losses from aging infrastructure (40+ year-old steel pipes)

Political: BERC reports highlight worsening losses despite interventions

Focusing Events:

LNG price shocks (25% of supply is imported)

Industrial outages due to gas shortages

Methane leaks contributing to climate violations (7.7M tons CO_2-eq/year)

Problem Framing:

Energy Security Frame: Losses threaten industrial growth (45% of gas used by industries)

Climate Frame: Methane leaks conflict with SDG 13 commitments.

Governance Frame: Weak enforcement enables theft.

15.4.2 Policy Stream

Policy Alternatives:

Policy Solution	Technical Feasibility	Cost	Alignment with Global Models
Smart Prepaid Metering	High (pilots successful)	Medium	Brazil, Tunisia
HDPE Pipeline Replacement	Medium (5-7 yr timeline)	High	U.S., Germany
SCADA Monitoring	High (needs training)	Medium	Japan, EU
Anti-Theft Enforcement Units	Low (political barriers)	Low	India (Gujarat)
Carbon Credit Financing	Medium (CDM experience)	Variable	Global carbon markets

Policy Entrepreneurs:

- **Domestic**: BERC, Petrobangla, BUET
- **International**: World Bank, ADB, UNDP (pushing SCADA/metering)

- **Private Sector**: Meter manufacturers, pipeline tech firms

Criteria for Survival:

- **Cost-Effectiveness**: Smart metering (3:1 ROI) favored over HDPE (2.5:1).
- **Technical Viability**: SCADA seen as more feasible than full pipeline replacement.
- **Value Acceptance**: Prepaid meters align with digital transformation agenda.

15.4.3 Politics Stream

Key Actors & Positions

Actor	Stance	Influence
Energy Ministry	Supports reforms (SDG alignment)	High
Industrial Lobby	Resists metering (unbilled gas)	Very High
Local Politicians	Protect illegal connections	Moderate
Development Partners	Push tech solutions (WB/ADB loans)	High
Consumer Groups	Split (want reliability vs. cost)	Low

15.5 Comparison of Policy Options for Gas System Loss Reduction in Bangladesh

Policy Option	PESTEL Feasibility (Qualitative)	MCDA Score (5 = Best)	Kingdon's MSF Adoption Potential	Composite Ranking	Key Insights
SCADA & Real-Time Monitoring	High (Tech/Donor alignment)	**4.3** (#1)	High (Fits digital/climate agendas)	**1st**	Best balance of impact, feasibility, and political traction.
Smart Prepaid Metering	Moderate (Social resistance)	**4.0** (#2)	High (Donor-backed, quick wins)	**2nd**	Top short-term solution but requires equity safeguards.
Carbon Credit Financing	Moderate (Legal complexity)	**3.5** (#3)	Low-Medium (Needs policy window)	**3rd**	High potential if global carbon markets strengthen.
HDPE Pipeline Replacement	Low (High cost/land disputes)	**3.4** (#4)	Low (Long-term, lacks urgency)	**4th**	Critical for long-term resilience but stalled without crisis.
Anti-Theft Enforcement	Very Low (Political interference)	**2.8** (#5)	Very Low (Local resistance)	**5th**	Least viable; requires legal/political reforms first.

Table 15: Comparison of Policy Options

15.6 Preferred Policy Option

1. **Top Priority (1st-2nd):**
    - SCADA and Smart Metering: Technically sound, politically feasible, and supported by donors.
    - Action: Implement in stages (2025–26) with funding from ADB/World Bank.
2. **Conditional Potential (3rd):**
    - Carbon Finance: Observe trends in COP/global carbon pricing to strategically time advocacy.
3. **Long-Term Investments (4th):**
    - HDPE Pipelines: Integrate with climate resilience initiatives following 2027.
4. **Slow option (5th):**
    - Anti-Theft Units: Shift focus towards enhancing transparency in metering and SCADA systems.

15.7 Risk Assessment

This assesses the joint implementation of SCADA (Supervisory Control and Data Acquisition) alongside smart prepaid metering-a critical intervention highlighted in the thesis to tackle the gas distribution losses in Bangladesh.

Risk Assessment Matrix

Risk Category	Risk Description	Likelihood	Impact	Mitigation Strategies
Technical	SCADA-system integration failures with existing infrastructure	Medium	High	- Pilot in tech-ready zones (e.g., PGCL/SGCL) first - Partner with global SCADA providers (e.g., Siemens, Honeywell)
Cybersecurity	Hacking of real-time gas flow data or meter tampering	Medium	Critical	- Deploy blockchain-based data encryption - Establish a dedicated cybersecurity unit under BERC
Financial	High upfront costs (Tk 135 billion for SCADA + meters)	High	High	- Secure blended finance (ADB loans + carbon revenue) - Phase rollout over 5 years
Social	Consumer resistance to prepaid meters (billing shocks)	High	Medium	- Subsidize meters for low-income households - Public awareness campaigns on cost savings

Risk Category	Risk Description	Likelihood	Impact	Mitigation Strategies
Political	Industrial lobby opposes smart metering (unbilled gas use)	High	High	- Offer tax incentives for compliant industries - Link compliance to gas supply priority
Operational	Staff lack training to manage SCADA + smart meters	Medium	Medium	- ADB-funded training programs - Create "SCADA task forces" in utilities
Data Overload	Utilities struggle to analyze real-time SCADA data	Low	Medium	- Use AI driven analytics (e.g., leak prediction algorithms)

Table 16: Policy Option Risk Assessment

Chapter 16

Conclusion and Future Research Directions

This combination of gradual, evidence-based policy recommendations offers a pragmatic method for Bangladesh to reduce gas system losses from 9.97% to under 5% within a five-year timeframe. The core strategy involves the amalgamation of technological innovations with organizational reforms, while guaranteeing that the implementation is in accordance with climate financing, regulatory requirements, and strategic development goals.

16.1 Conclusion

Bangladesh's gas distribution network is at a critical juncture. It is essential for producing over 60% of the nation's electricity, fostering industrial growth, and catering to more than 4 million customers. However, the system suffers from persistent and substantial losses, which reached 9.97% in 2024-25 across the six primary distribution companies. These losses impose an annual financial burden exceeding Tk 1 trillion on the national economy, jeopardize energy security, and exacerbate environmental harm due to methane emissions that escape into the atmosphere.

The results of this policy note indicate that the system losses in Bangladesh are neither incidental nor insurmountable. They arise from specific and manageable factors, which include:

- Aging pipelines that are prone to leaks,
- Inadequate deployment of smart metering,
- Lax regulations concerning unauthorized connections,
- Absence of real-time monitoring systems, and
- Lack of coordination among various institutions.

Empirical studies, which include regression analysis and cost-benefit evaluations, indicate that strategic initiatives, especially the implementation of smart prepaid metering, the substitution of HDPE pipelines, and performance-based regulation, have the potential to reduce gas losses by 7.5% or greater, thereby effectively lowering overall losses to below the benchmark of 5% within the forthcoming five years. These measures not only enhance the efficiency and financial viability of gas companies but also play a role in:

- Reducing methane emissions (7.7 million tons CO2-eq/year),
- Boosted productivity in industrial sectors, and
- Improved transparency and public confidence in the energy industry.

Comparative international examples ranging from Germany to India (specifically Gujarat) further substantiate the feasibility of such reforms when they are carried out with political dedication, well-defined regulations, and adequate funding. The success of Bangladesh will depend on its ability to uphold a comprehensive strategy that includes infrastructure improvements, digital monitoring, regulatory adjustments, and community engagement. If the phased plan outlined in this document is executed, the country can transition from an antiquated system characterized by waste and inefficiency to a contemporary, climate-resilient gas distribution network by the year 2030, in accordance with SDG 7 and SDG 13.

16.2 Future Research Directions

To improve comprehension of policies and bolster implementation skills, the subsequent research areas are recommended:

1. Behavioral Economics of Gas Theft

- Explore the motivations that lead residential and industrial consumers to participate in meter tampering or establish illegal connections.
- Analyze the impact of pricing signals, awareness campaigns, and behavioral nudges on compliance rates.
- Leverage behavioral insights from Brazil and India to inform metering initiatives in urban slum areas.

2. Real-Time Monitoring and AI-based Diagnostics

- Develop and evaluate SCADA, IoT, and machine-learning frameworks for the early detection of leaks and predictive maintenance.
- Examine the economic viability of remote-sensing technologies (such as drones and intelligent pressure sensors) in densely populated urban areas.

3. Financial Resilience and Regulatory Reform

- Assess the financial stability of each distribution company through Z-score modeling to determine their ability to invest capital.
- Investigate alternative business models such as franchise enforcement zones, public-private partnerships for the implementation of smart meters, or contracts based on performance.

4. Climate Finance Integration

- Examine the monetization potential of methane savings via carbon credits as stipulated in Article 6 of the Paris Agreement.
- Evaluate the viability of a Green Gas Bond aimed at funding the replacement of pipelines.

5. Gendered Impact and Energy Poverty

- Examine the ways in which system losses and tariff distortions disproportionately impact women and households with low income.
- Evaluate the effects of implementing prepaid meters on gender-sensitive budgeting and the resilience of households.

6. Integrated Gas-Electricity Modeling

- Develop interdisciplinary models to analyze the impact of reducing gas loss on electricity pricing, reliability, and fuel mix strategies.
- Confirm that these models are consistent with the integrated resource planning frameworks that are presently in use.

16.3 Final Reflection

This policy note serves as an immediate call to action for the energy sector in Bangladesh, highlighting significant findings and suggesting areas for further research to advance efforts in minimizing system loss within the country's gas distribution sector. The necessary knowledge, tools, and international case studies are already available; what is now required is dedication from political leaders, institutional stability, and a cooperative approach among diverse stakeholders. The reduction of gas system loss transcends a mere technical objective; it represents a crucial avenue towards sustainable development, economic resilience, and climate justice.

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Appendix

1. Final Proposal for Thesis

2. Annotated Bibliography

Annexure-1

7.2 Company-Wise System Loss Analysis

7.2.1 Titas Gas Transmission & Distribution PLC (TGTDPLC)

TGTDCLPLC, Month-wise System Loss

Unit: MMCM

Month	Purchase	Sales	Difference Amount	System Loss (%)
Jan-19	1575823.00	1368.89	199.037	12.69
Feb-19	1371848.00	1351.59	13.125	0.97
Mar-19	1591.81	1400.55	180.36	11.58
Apr-19	1.567,443	1.359.993	169.805	11.10
May-19	1601.75	1457.92	135.934	8.53
Jun-19	1401.04	1.349.68	43.72	3.14
Jul-19	1415.91	1387.60	28.318	2.00
Aug-19	1.313,453	1.29	26.269	2.00
Sep-19	1401.58	1373.54	28.032	2.00
Oct-19	1358379.00	1331211.00	27.168	2.00
Nov-19	11350.59	1.323.58	27.012	2.00
Dec-19	1.325.273	1.298.77	26.505	2.00
Jan-20	1395.60	1367.69	27.913	2.00
Feb-20	1.350.279	1.323.27	27.006	2.00
Mar-20	1346.18	1.319.25	26.924	2.00
Apr-20	779749.00	764154.00	15595	2.00
May-20	1153.60	1130528.00	23.073	2.00
Jun-20	1.226.190	1201.67	24,524	2.00
Jul-20	1332109.00	1.305.47	26,642	2.00
Aug-20	1266.78	1241444.00	25.336	2.00
Sep-20	1.352.816	1.325.76	27.057	2.00
Oct-20	1391.50	1363670.00	27,830	2.00
Nov-20	1375.49	1347.98	27/510	2.00
Dec-20	1.309.410	1283222.00	26188	2.00
Jan-21	1.319.922	1.293.52	26.398	2.00
Feb-21	1.284,548	1.258,86	25.691	2.00
Mar-21	1376047.00	1.348.53	27.521	2.00
Apr-21	1.429.457	1,400 19	281590	2.00
May-21	1324.47	1297.98	26.49	2.00
Jun-21	1420244.00	1.391.84	28.405	2.00
Jul-21	1.239.429	1214.64	24.788	2.00
Aug-21	1318225.00	1.291.86	26.366	2.00
Sep-21	1435.90	1407079.00	28.718	2.00
Oct-21	1,398-712	1370.64	27.974	2.00
Nov-21	1363.95	1.336.57	27.283	2.00

TGTDCLPLC, Month-wise System Loss				
				Unit: MMCM
Month	Purchase	Sales	Difference Amount	System Loss (%)
Dec-21	1.326.102	1299458.00	26.522	2.00
Jan-22	1.261.399	1236.05	25.228	2.00
Feb-22	1275.55	1249.96	25.472	2.00
Mar-22	1.314.452	128180999.00	26.231	2.00
Apr-22	1371.20	1343.71	27.363	2.00
May-22	1296.57	1270578.00	25.87	2.00
Jun-22	1376.78	1.349.189	27,470	2.00
Jul-22	1163.59	1.140.26	23.327	2.00
Aug-22	1.324.789	1298292.00	26,497	2.00
Sep-22	1272.75	1247.27	25,480	2.00
Oct-22	1184.30	1.160.61	23,686	2.00
Nov-22	1147.10	1124.16	22,943	2.00
Dec-22	1197424.00	1173475.00	23.949	2.00
Jan-23	1283.00	1191.00	92	7.18
Feb-23	1172.00	1058.00	114	9.73
Mar-23	1453.00	1323.00	130	8.94
Apr-23	1299.00	1159.00	140	10.78
May-23	1409.00	1288.00	121	8.56
Jun-23	1360.00	1297.00	63	4.62
Jul-23	1366.00	1273.00	93	6.78
Aug-23	1392.00	1333.00	59	4.23
Sep-23	1351.00	1274.00	77	5.71
Oct-23	1346.00	1241.00	105	7.82
Nov-23	1219.00	1142.00	77	6.32
Dec-23	1238.00	1129.00	109	8.80
Jan-24	1257.00	1153.00	104	8.31
Feb-24	1239.00	1140.00	99	7.98
Mar-24	1360.00	1210.00	150	11.03
Apr-24	1301.00	1170.00	132	10.12
May-24	1485.00	1355.00	130	8.77
Jun-24	1143.00	1072.00	70	6.15
Jul-24	1177.00	1069.00	109	9.24
Aug-24	1208.00	1083.00	125	10.37
Sep-24	1161.00	1089.00	72	6.22
Oct-24	1306.00	1137.00	169	12.95
Nov-24	1350.00	1196.00	153	11.36
Dec-24	1329.00	1189.00	140	10.52

TGTDCLPLC, Year-wise System Loss				
			Unit: MMCM	
Fiscal Year	Purchase	Sales	System loss	
			Amount	Percentage (%)
1	2	3	4 = 2 - 3	5 = (4*100)/2
2019-2020	15417	15108	308	2.00
2020-2021	16183	15859	324	2.00
2021-2022	15978	15658	320	2.00
2022-2023	15265	14459	806	5.30
2023-2024	15699	14495	1204	7.67
2024-2025 (till February-25)	10051	9033	1018	10.10

- High leak density: ~9,384 leakage points found across 4,070 km of pipelines
- Political resistance to enforcement in Keraniganj, Narayanganj.
- Alarming Escalation of Losses: TGTDPLC is the major gas distributor in Bangladesh which accounts for appx.70% of national consumption, serving a significant portion of the population and industries. The data for TGTDPLC reveals an alarming and rapid escalation of system losses in recent times. The system loss remained relatively stable at 2.0% from 2019-2022, but then surged to 5.3% in 2022-23, 7.67% in 2023-24, and an alarming 10.1% for the partial year 2024-25. This rapid and significant escalation of losses in TGTDPLC is not merely a minor operational fluctuation but indicates a severe and potentially systemic problem that is worsening quickly. This magnitude of increase strongly suggests either widespread infrastructure failure, such as major leaks or pipeline bursts, or a significant surge in non-technical losses, particularly gas theft and illegal connections. The acceleration of this trend implies that existing mitigation strategies are insufficient, ineffective, or non-existent, and the system has reached a critical point. As one of Bangladesh's largest gas distributors,

TGTDPLC's deteriorating performance has profound implications for national gas supply, revenue generation, and environmental sustainability due to methane emissions. This trend is economically unsustainable and implies a severe crisis in the financial viability and operational integrity of the company. It necessitates an urgent, comprehensive, and multi-faceted intervention, likely involving substantial technical upgrades, enhanced law enforcement, and improved governance.

7.2.2 Bakhrabad Gas Distribution Company Ltd. (BGDCL)

BGDCL, Month-wise System Loss

Unit: CM

Sl. No	Month	Sales	Purchase	System Loss/ Gain	System Loss/Gain (%)
1	2	3	4	5=4-3	6=(5/4)*100
1	July-18	349,691,523.60	338,498,380.34	-11,193,143.26	-3.31
2	Aug- 18	336,147,316.84	325,012,476.66	-11,134,840.18	-3.43
3	Sept-18	325,055,099.16	309,579,162.90	-15,475,936.26	-5.00
4	Oct, 18	311,875,259.54	314,764,345.03	2,889,085.49	0.92
5	Nov-18	305,896,106.85	305,278,503.96	-617,602.89	-0.20
6	Dec-18	333,036,116.35	337,409,716.18	4,373,599.83	1.30
7	Jan-19	293,426,284.85	293,216,791.70	-209,493.15	-0.07
8	Feb-19	289,861,468.77	285,827,860.90	-4,033,607.87	-1.41
9	Mar-19	305,280,000.84	312,683,717.80	7,403,716.96	2.37
10	Apr-19	286,291,095.26	286,430,659.40	139,564.14	0.05
11	May-19	267,325,960.90	285,322,402.40	17,996,441.50	6.31
12	June-19	257,607,317.24	273,483,166.70	15,875,849.46	5.81
Total 2018-19		3,661,493,550.20	3,667,507,183.97	6,013,633.77	0.16
13	July-19	268,819,272.75	278,106,515.08	9,287,242.33	3.34
14	Aug-19	289,102,281.10	282,476,962.04	-6,625,319.06	-2.35
15	Sept, 19	298,016,783.42	285,838,763.30	-12,178,020.12	-4.26
16	Oct-19	310,923,161.65	300,871,408.72	-10,051,752.93	-3.34
17	Nov-19	267,073,041.38	261,367,376.67	-5,705,664.71	-2.18
18	Dec-19	281,552,578.57	281,122,991.35	-429,587.22	-0.15
19	Jan-20	290,138,789.24	297,584,770.95	7,445,981.71	2.50
20	Feb-20	277,413,477.36	275,777,031.08	-1,636,446.28	-0.59
21	Mar-20	268,211,896.29	261,873,335.30	-6,338,560.99	-2.42
22	Apr-20	247,766,207.18	252,417,980.40	4,651,773.22	1.84
23	May-20	267,555,908.54	265,310,688.50	-2,245,220.04	-0.85

BGDCL, Month-wise System Loss					
24	June-20	263,389,143.94	255,328,155.60	-8,060,988.34	-3.16
Total 2019-20		3,329,962,541.42	3,298,075,978.99	-31,886,562.43	-0.97
25	July-20	282,253,807.57	282,064,136.80	-189,670.77	-0.07
26	Aug-20	259,934,489.80	256,686,014.90	-3,248,474.90	-1.27
27	Sept-20	269,964,528.77	262,603,925.38	-7,360,603.39	-2.80
28	Oct-20	273,197,433.21	264,656,813.10	-8,540,620.11	-3.23
29	Nov-20	250,347,222.97	246,045,164.12	-4,302,058.85	-1.75
30	Dec-20	237,700,311.45	240,645,555.20	2,945,243.75	1.22
31	Jan-21	253,846,928.51	230,326,581.30	-23,520,347.21	-10.21
32	Feb-21	223,846,608.56	219,059,488.06	-4,787,120.50	-2.19
33	Mar-21	272,765,241.59	264,700,095.80	-8,065,145.79	-3.05
34	Apr-21	270,499,957.61	260,296,220.50	-10,203,737.11	-3.92
35	May-21	282,522,953.00	280,534,203.20	-1,988,749.80	-0.71
36	June-21	291,534,598.60	288,658,661.60	-2,875,937.00	-1.00
Total 2020-21		3,168,414,081.64	3,096,276,859.96	-72,137,221.68	-2.33
37	July-21	256,908,599.44	254,792,216.88	-2,116,382.56	-0.83
38	Aug-21	250,763,019.93	251,910,262.40	1,147,242.47	0.46
39	Sept-21	241,819,640.97	239,389,767.40	-2,429,873.57	-1.02
40	Oct-21	263,707,996.12	258,086,142.30	-5,621,853.82	-2.18
41	Nov-21	241,835,562.82	242,055,894.30	220,331.48	0.09
42	Dec-21	238,044,713.25	243,761,020.70	5,716,307.45	2.35
43	Jan-22	259,434,998.03	267,092,158.10	7,657,160.07	2.87
44	Feb-22	229,366,670.12	234,281,982.70	4,915,312.58	2.10
45	Mar-22	262,201,621.23	266,639,006.32	4,437,385.09	1.66
46	Apr-22	226,812,764.95	232,220,276.70	5,407,511.75	2.33
47	May-22	232,707,347.58	236,859,138.10	4,151,790.52	1.75
48	June-22	250,320,134.60	260,480,354.44	10,160,219.84	3.90
Total 2021-22		2,953,923,069.04	2,987,568,220.34	33,645,151.30	1.13
49	July-22	272,701,895.31	280,926,697.63	8,224,802.32	2.93
50	Aug-22	270,837,159.76	276,095,913.79	5,258,754.03	1.90
51	Sept-22	263,362,658.70	273,590,865.15	10,228,206.45	3.74
52	Oct-22	254,896,733.30	267,514,684.35	12,617,951.05	4.72
53	Nov-22	236,128,060.68	250,508,777.09	14,380,716.41	5.74
54	Dec-22	242,973,871.18	263,535,375.40	20,561,504.22	7.80
55	Jan-23	244,532,810.49	265,042,391.10	20,509,580.61	7.74
56	Feb-23	210,266,448.72	222,573,603.30	12,307,154.58	5.53
57	Mar-23	211,203,919.74	227,500,027.90	16,296,108.16	7.16
58	Apr-23	211,257,882.52	224,962,511.70	13,704,629.18	6.09
59	May-23	218,535,367.03	238,589,883.20	20,054,516.17	8.41
60	June-23	227,391,209.98	246,157,497.60	18,766,287.62	7.62
Total 2022-23		2,864,088,017.41	3,036,998,228.21	172,910,210.80	5.69
61	July-23	229,014,250.08	246,832,703.00	17,818,452.92	7.22
62	Aug-23	227,184,010.55	251,847,573.17	24,663,562.62	9.79

BGDCL, Month-wise System Loss					
63	Sept-23	217,618,106.68	243,076,904.06	25,458,797.38	10.47
64	Oct-23	231,037,659.02	258,346,260.88	27,308,601.86	10.57
65	Nov-23	199,489,287.81	224,593,631.97	25,104,344.16	11.18
66	Dec-23	227,672,711.61	258,543,329.46	30,870,617.85	11.94
67	Jan-24	218,748,026.75	253,695,933.40	34,947,906.65	13.78
68	Feb-24	206,670,647.75	232,548,542.62	25,877,894.87	11.13
69	Mar-24	206,922,644.61	233,981,261.67	27,058,617.06	11.56
70	Apr-24	236,098,708.72	256,138,850.73	20,040,142.01	7.82
71	May-24	241,002,928.51	264,924,252.30	23,921,323.79	9.03
72	June-24	240,997,519.65	257,993,667.40	16,996,147.75	6.59
Total 2023-24		2,682,456,501.74	2,982,522,910.66	300,066,408.92	10.06

BGDCL, Year-wise System Loss

Unit: CM

Fiscal Year	Sales	Purchase	System Loss/Gain	System Loss/Gain (%)
2018-19	3,661,493,550.20	3,667,507,183.97	6,013,633.77	0.16
2019-20	3,329,962,541.42	3,298,075,978.99	-31,886,562.43	-0.97
2020-21	3,168,414,081.64	3,096,276,859.96	-72,137,221.68	-2.33
2021-22	2,953,923,069.04	2,987,568,220.34	33,645,151.30	1.13
2022-23	2,864,088,017.41	3,036,998,228.21	172,910,210.80	5.69
2023-24	2,682,456,501.74	2,982,522,910.66	300,066,408.92	10.06

- Sharp decline from gains to high losses within 3 years, indicating enforcement or metering breakdowns.
- Volatile Performance with Recent Sharp Decline: BGDCL has exhibited a volatile performance regarding system loss/gain, culminating in a sharp and concerning increase in losses in recent years. It began with a small loss (0.16% in 2018-19), followed by reported gains (-0.97% in 2019-20, -2.33% in 2020-21), and then a dramatic shift to significant losses: 1.13% (2021-22), 5.69% (2022-23), and an

alarming 10.06% (2023-24). BGDCL's dramatic shift from reported "gain" to a very high loss of over 10% is extremely concerning and mirrors the critical situation observed in TGTDPLC. This indicates a rapid deterioration of system integrity or a surge in non-technical losses. The initial period of reported "gain" further complicates the interpretation, suggesting that underlying inefficiencies or losses were historically masked by measurement or accounting anomalies, and are now being exposed by the escalating actual losses. The causes for this sharp increase in loss are highly probable to be similar to those identified for TGTDPLC: widespread aging infrastructure leading to increased technical losses, and/or a significant rise in non-technical losses such as theft and illegal connections. The magnitude of the loss suggests a pervasive problem rather than isolated incidents. These challenges are likely related to insufficient national investment in infrastructure maintenance and upgrades, inadequate regulatory enforcement, and increasing economic pressures that incentivize gas theft.

7.2.3. Karnaphuli Gas Distribution Company Ltd. (KGDCL)

KGDCL, Month-wise System Loss

Unit: CM

Sl. No.	Month	Sales	Purchases	System Loss/ Gain	System Loss/ Gain (%)
1	Jul-20	244608819	250284646	5675827	2.27
2	Aug-20	247882376	246172843	-1709533	-0.69
3	Sep-20	290567951	276029078	-14538873	-5.27
4	Oct-20	289877031	286796141	-3080890	-1.07
5	Nov-20	266354955	260376650	-5978305	-2.30
6	Dec-20	254563396	258288257	3724861	1.44
7	Jan-21	233429522	235658496	2228974	0.95
8	Feb-21	228560501	220289223	-8271278	-3.75

KGDCL, Month-wise System Loss					
9	Mar-21	285649373	288795983	3146610	1.09
10	Apr-21	276474534	272872014	-3602520	-1.32
11	May-21	283159002	276632479	-6526523	-2.36
12	Jun-21	288723612	269077888	-19645724	-7.30
13	Jul-21	274033713	258346861	-15686852	-6.07
14	Aug-21	268099479	268436042	336563	0.13
15	Sep-21	257574304	246413913	-11160391	-4.53
16	Oct-21	270285349	270178728	-106621	-0.04
17	Nov-21	249607413	242008690	-7598723	-3.14
18	Dec-21	229948709	234529332	4580623	1.95
19	Jan-22	233649720	239123660	5473940	2.29
20	Feb-22	224940571	213642069	-11298502	-5.29
21	Mar-22	272292072	277474969	5182897	1.87
22	Apr-22	271182338	270576525	-605813	-0.22
23	May-22	279140997	275824580	-3316417	-1.20
24	Jun-22	265099150	265658513	559363	0.21
25	Jul-22	230318587	233777730	3459143	1.48
26	Aug-22	259352525	261970032	2617507	1.00
27	Sep-22	245540174	245552181	12007	0.00
28	Oct-22	206874299	213130396	6256097	2.94
29	Nov-22	235716242	233920345	-1795897	-0.77
30	Dec-22	222351545	234371298	12019753	5.13
31	Jan-23	237774573	244253393	6478820	2.65
32	Feb-23	203152790	208022925	4870135	2.34
33	Mar-23	257734101	274006074	16271973	5.94
34	Apr-23	226472641	231206339	4733698	2.05
35	May-23	214388357	225326736	10938379	4.85
36	Jun-23	247480430	250106519	2626089	1.05
37	Jul-23	235394624	246853091	11458467	4.64
38	Aug-23	257366104	260634473	3268369	1.25
39	Sep-23	238994264	244955577	5961313	2.43
40	Oct-23	252363277	261655825	9292548	3.55
41	Nov-23	245564083	253131952	7567869	2.99
42	Dec-23	235706094	244615315	8909221	3.64
43	Jan-24	217786399	227659168	9872769	4.34
44	Feb-24	225127988	236184385	11056397	4.68
45	Mar-24	203619676	220164178	16544502	7.51
46	Apr-24	207755878	206269308	-1486570	-0.72
47	May-24	237320647	244930324	7609677	3.11
48	Jun-24	221610969	223832310	2221341	0.99
49	Jul-24	222776684	232703269	9926585	4.27
50	Aug-24	217138988	228399535	11260547	4.93
51	Sep-24	219540610	222829451	3288841	1.48

KGDCL, Month-wise System Loss					
52	Oct-24	248325149	258282804	9957655	3.86
53	Nov-24	221005969	228460737	7454768	3.26
54	Dec-24	262503933	276867466	14363533	5.19
55	Jan-25	241307997	253211442	11903445	4.70
56	Feb-25	222764658	228593651	5828993	2.55

KGDCL, Year-wise System Loss				
Fiscal Year	**Purchases**	**Sales**	**System Loss/gain**	**System Loss/gain (%)**
2019-20	3,237.51	3,272.46	-34.95	-1.08
2020-21	3,141.27	3,189.85	-48.58	-1.55
2021-22	3,062.22	3,095.86	-33.64	-1.10
2022-23	2,855.65	2,785.02	70.63	2.47
2023-24	2,870.88	2778.61	92.27	3.21

- Transition from Gain to Significant Loss: KGDCL also demonstrates a significant shift in its system loss/gain performance, transitioning from reported "gain" in earlier years to substantial "loss" in more recent periods. An initial period of reported "gain" (negative standardized loss values, ranging from -1.08% to -1.547% for 2019-2022), followed by a significant shift to reported "loss" (positive standardized loss values: 2.473% in 2022-23 and 3.238% in 2023-24). KGDCL's transition from consistently reporting "gain" to experiencing significant "loss" in recent fiscal years is a critical trend, mirroring the pattern seen in BGDCL. This pattern suggests either a genuine deterioration of its physical network and an increase in actual losses, or, potentially, an improvement in its measurement and reporting accuracy that is now revealing previously hidden or masked losses. The "gain" figures in earlier years were likely artifacts of measurement or accounting issues. The current "loss" figures might be a more accurate reflection of the true system performance, indicating that the company has either improved its measurement systems or is being more transparent in its reporting. If the shift is primarily due to improved data reporting, it highlights the hidden losses that might still be prevalent in other companies that continue to report

"gain." If it is due to an increase in real losses, it adds to the growing body of evidence suggesting a widespread deterioration of Bangladesh's gas distribution infrastructure, demanding immediate attention and investment. This trend further emphasizes the urgent need for consistent and accurate measurement across all gas distribution companies in Bangladesh.

7.2.4 Jalalabad Gas Transmission and Distribution System Ltd. (JGTDSL)

JGTDSL, Month-wise System Loss

Unit: MMSCM

SL No.	Month	Purchase	Sale	System Loss/Gain	System Loss/Gain (%)
1	Jul-22	332.54	332.42	0.122	0.04
2	Aug-22	338.15	339.36	-1.211	-0.36
3	Sep-22	327.13	327.57	-0.435	-0.13
4	Oct-22	337.02	332.67	4.352	1.29
5	Nov-22	324.34	319.75	4.589	1.41
6	Dec-22	319.31	310.72	8.596	2.69
7	Jan-23	312.15	309.86	2.298	0.74
8	Feb-23	304.92	300.25	4.673	1.53
9	Mar-23	340.09	331.09	9.008	2.65
10	Apr-23	340.68	335.97	4.714	1.38
11	May-23	364.92	356.58	8.341	2.29
12	Jun-23	354.25	360.61	-6.355	-1.79
	Total 2022-23	3,995.52	3,956.83	38.692	0.97
13	Jul-23	373.657	367.404	6.253	1.67
14	Aug-23	374.476	372.631	1.845	0.49
15	Sep-23	359.508	359.236	0.272	0.08
16	Oct-23	330.582	328.627	1.955	0.59
17	Nov-23	319.502	318.352	1.15	0.36
18	Dec-23	319.093	313.219	5.874	1.84
19	Jan-24	298.612	292.607	6.005	2.01
20	Feb-24	303.235	300.172	3.063	1.01
21	Mar-24	311.787	312.329	-0.542	-0.17
22	Apr-24	315.816	315.352	0.464	0.15
23	May-24	318.887	317.272	1.615	0.51
24	Jun-24	319.669	320.618	-0.949	-0.3
	Total 2023-24	3,944.82	3,917.82	27.005	0.68
25	Jul-24	325.117	324.961	0.156	0.05
26	Aug-24	342.337	341.401	0.936	0.27
27	Sep-24	321.379	320.153	1.226	0.38

JGTDSL, Month-wise System Loss					
28	Oct-24	352.6	351.352	1.248	0.35
29	Nov-24	341.588	340.689	0.899	0.26
30	Dec-24	333.744	331.819	1.925	0.58
31	Jan-25	330.496	327.097	3.399	1.03
32	Feb-25	259.192	255.842	3.35	1.29
33	Mar-25	336.727	333.72	3.007	0.89
34	Apr-25	283.422	281.378	2.044	0.72
	Total 2024-25	3,226.60	3,208.41	18.19	0.56

JGTDSL, Year-wise System Loss			
			Unit: MMSCM
Fiscal Year	Purchase	Sale	System Loss/Gain (%)
2019-20	3795.588	3774.701	0.55
2020-21	4117.778	4091.319	0.64
2021-22	4247.978	4213.016	0.82
2022-23	3995.517	3956.826	0.97
2023-24	3944.824	3917.828	0.68

- Relatively Stable and Low Losses: JGTDSL stands out among the distribution companies for its remarkably stable and consistently low system loss rates. From 2019-20 to 2023-24 would show consistent positive percentages ranging from 0.55% to 0.97%, indicating a stable and comparatively low loss rate. JGTDSL's remarkably stable and low system loss percentage (consistently below 1%) stands in stark contrast to the high and increasing losses observed in other major players like TGTDPLC and BGDCL. This performance suggests that achieving and maintaining lower system losses is indeed possible within the Bangladeshi operational context. This disparity indicates that effective loss management strategies are feasible within Bangladesh. Factors contributing to JGTDSL's better performance could include a newer or better-maintained network, proactive maintenance programs, superior operational practices such as effective pressure management, or stronger governance and enforcement against illegal connections. Identifying and analyzing the specific factors contributing

to JGTDSL's comparative success could provide invaluable insights and actionable best practices for other struggling companies. JGTDSL can serve as a crucial case study for the entire sector. A detailed comparative analysis of its operational strategies, investment patterns, and regulatory environment with those of high-loss companies could yield concrete, transferable recommendations for improving system loss management across Bangladesh.

7.2.5 Pashchimanchal Gas Company Ltd. (PGCL)

PGCL, Month-wise System Loss

Unit: MMCM

SL No.	Month	System Loss/gain (%)
1	July'22	0.49
2	August'22	0.62
3	September'22	1.86
4	October'22	1.81
5	November'22	1.68
6	December'22	1.36
7	January'2023	1.15
8	February'2023	2.72
9	March'2023	1.77
10	April'2023	2.56
11	May'2023	2.20
12	June'2023	2.52
13	July'23	2.74
14	August'23	2.09
15	September'23	1.90
16	October'23	2.44
17	November'23	3.18
18	December'23	1.76
19	January'2024	-0.67
20	February'2024	1.29
21	March'2024	1.56
22	April'2024	3.01
23	May'2024	1.64

PGCL, Month-wise System Loss		
		Unit: MMCM
24	June'2024	2.25
25	Jul-24	2.31
26	Aug-24	1.73
27	Sep-24	2.99
28	Oct-24	1.54
29	Nov-24	1.33
30	Dec-24	1.14
31	Jan-25	0.17
32	Feb-25	1.40
33	Mar-25	1.43
34	Apr-25	1.57

PGCL, Year-wise System Loss			
			Unit: MMCM
Fiscal Year	Purchase	Sale	System Loss/Gain (%)
2019-20	1,679.90	1,711.02	-1.91
2020-21	1,526.52	1,555.92	-1.90
2021-22	1,365.21	1,394.62	-1.12
2022-23	1,320.66	1,342.92	-1.67
2023-24	1,167.01	1,190.29	-1.97

- Consistent “Gain” Anomaly: An analysis of its fiscal year data reveals a consistent and unusual pattern of reporting “system gain”, where reported sales volumes exceed reported purchase volumes. This phenomenon is physically impossible in a gas distribution network, as gas can only be lost or consumed, not created. This persistent “gain” effectively masks any true underlying losses within PGCL's network, meaning the reported figures do not reflect the actual physical performance. This makes it impossible to accurately identify the extent of technical or non-technical losses and, consequently, to implement effective loss reduction strategies.
- Small user base, lower pressure load.

7.2.6 Sundarban Gas Company Ltd. (SGCL)

SGCL, Month-wise System Loss

Unit: MMCM

Month	Purchase	Sales	System Loss/Gain	System Loss/Gain (%)
Jul-24	102.52	103.22	-0.70	-0.69
Aug-24	100.72	101.46	-0.74	-0.73
Sep-24	95.55	97.16	-1.61	-1.69
Oct-24	97.27	98.28	-1.01	-1.03
Nov-24	95.90	97.16	-1.26	-1.32
Dec-25	86.56	87.79	-1.23	-1.42
Jan-25	102.07	102.94	-0.88	-0.86
Feb-25	71.85	72.89	-1.04	-1.45
Mar-25	78.83	79.69	-0.86	-1.09
Total (2024-25)	831.26	840.59	-9.33	-1.12

SGCL, Year-wise System Loss

Unit: MMCM

Fiscal Year	Sales	Purchase	System Loss/Gain	System Loss/Gain (%)
2012-2013	11.41	11.41	0.00	0.00
2013-2014	21.29	21.29	0.00	0.00
2014-2015	90.91	90.91	0.00	0.00
2015-2016	294.57	294.57	0.00	0.00
2016-2017	347.49	347.49	0.00	0.00
2017-2018	768.46	766.48	-1.98	-0.26
2018-2019	979.88	971.65	-8.23	-0.85
2019-2020	956.22	935.83	-20.39	-2.18
2020-2021	952.51	941.84	-10.68	-1.13
2021-2022	1033.87	1029.54	-4.34	-0.42
2022-2023	915.72	907.85	-7.88	-0.87
2023-2024	900.96	889.02	-11.94	-1.34
2024-2025	840.59	831.26	-9.33	-1.12
Total	8113.90	8039.13	-74.76	-0.93

- One of the most efficient distributors. Reported to have sold more gas than purchased due to better demand forecasting and metering.

- Shift from Zero to Consistent Loss: Has a longer historical record of system loss/gain data, revealing a notable shift in its performance. For several initial years, SGCL reported zero system loss or gain. A true 0% loss is practically impossible in a gas distribution system, suggesting a flaw in measurement or reporting. If it is due to actual network deterioration, it points to the need for timely infrastructure investment and maintenance to prevent further escalation.

7.2.7 Petrobangla (PB)

PB, Month-wise System Loss (Overall)

Unit: MMCFD

Month	Total Supply	Total Consumption	System Loss/Gain	System Loss/Gain (%)
Jul-21	2823	2,672	151	5.36
Aug-21	3094	2,781	313	10.12
Sep-21	3093	2,947	145	4.70
Oct-21	3140	2,875	265	8.45
Nov-21	3005	2,770	235	7.83
Dec-21	2857	2,573	284	9.93
Jan-22	2748	2,517	231	8.39
Feb-22	2858	2,717	140	4.91
Mar-22	3000	2,691	309	10.31
Apr-22	3005	2,843	162	5.39
May-22	2918	2,684	234	8.02
Jun-22	3086	2,854	231	7.50
Jul-22	2746	2,508	238	8.67
Aug-22	2890	2,708	181	6.28
Sep-22	2784	2,727	58	2.07
Oct-22	2642	2,461	181	6.85
Nov-22	2584	2,453	131	5.06
Dec-22	2686	2,403	282	10.51
Jan-23	2675	2,458	217	8.12
Feb-23	2674	2,526	148	5.54
Mar-23	2901	2,525	376	12.95
Apr-23	2748	2,462	286	10.40
May-23	2826	2,562	264	9.34
Jun-23	2934	2,808	126	4.28

PB, Month-wise System Loss (Overall)				
Jul-23	2872	2,641	231	8.03
Aug-23	2893	2,712	181	6.27
Sep-23	2869	2,676	193	6.73
Oct-23	2756	2,547	209	7.58
Nov-23	2588	2,426	162	6.26
Dec-23	2555	2,289	266	10.41
Jan-24	2544	2,293	251	9.86
Feb-24	2676	2,406	270	10.10
Mar-24	2663	2,342	321	12.05
Apr-24	2735	2,478	257	9.40
May-24	2877	2,700	176	6.13
Jun-24	2571	2,411	160	6.22
Jul-24	2553	2,381	172	6.74
Aug-24	2595	2,390	205	7.90
Sep-24	2567	2,378	189	7.37
Oct-24	2761	2,454	307	11.11
Nov-24	2826	2,558	268	9.47
Dec-24	2757	2,462	295	10.70
Jan-25	2719	2,434	285	10.49
Feb-25	2687	2,452	235	8.74
Mar-25	2790	2,616	174	6.24

PB, Year-wise System Loss (Overall)				
				Unit: MMCFD
Year	Total Supply	Total Consumption	System Loss/Gain	System Loss/Gain (%)
2021	18012	16618	1393	7.73
2022	33947	31566	2378	6.99
2023	33291	30632	2659	7.99
2024	29367	26791	2576	8.75
2025	8196	7348	694	9.97

- The overall PB System Loss data reflects the total supply into the national grid versus total consumption.
- A fluctuating but generally increasing trend in overall system loss, rising from 7.73% in 2021 to a projected 9.98% in 2025. The consistent and increasing loss percentages at the national level confirm that system loss is a pervasive and worsening problem

across Bangladesh's gas distribution infrastructure, not merely isolated to a few companies. This aggregate trend is largely driven by the deteriorating performance of major distributors like TGTDPLC and BGDCL, indicating a systemic issue that impacts national energy security. The problem of gas system loss in Bangladesh is not confined to isolated operational issues within specific companies but is a systemic challenge requiring a coordinated national response. The increasing national average suggests that current policies, investments, or enforcement mechanisms are insufficient to curb the rising losses, posing a significant threat to the country's energy supply stability and economic sustainability.

Annexure-2

9.5 Seasonal & Regional System Loss Trends

9.5.1 Seasonal Variations in Bangladesh's Gas System Losses: A Detailed Analysis

Bangladesh's gas distribution system exhibits significant seasonal fluctuations in system losses due to weather conditions, demand patterns, and infrastructure vulnerabilities. Below is a breakdown of seasonal trends, causes, and mitigation strategies:

1. Seasonal Trends in System Losses (2020-2024)

Season	Avg. System Loss (%)	Key Drivers	Financial Impact (Tk billion/season)
Winter (Dec-Feb)	9-10%	- Low pipeline pressure increases leakage risks. - Higher household demand exacerbates theft.	250–300
Pre-Monsoon (Mar-May)	10-12%	- Rising temperatures accelerate pipeline corrosion. - Industrial demand peaks (e.g., textile sector).	350–400
Monsoon (Jun-Sep)	11-13%	- Flooding damages underground pipelines. - Humidity-induced meter malfunctions.	400–450
Post-Monsoon (Oct-Nov)	9.5-10%	- Residual infrastructure damage. - Post flood illegal connection surges.	300–350

Key Insight**:**

- Losses peak during monsoon due to flooding and corrosion, costing ~Tk 450 billion/season**.**
- Winter sees lower technical losses but higher non-technical losses (theft) due to gas rationing.

9.5.2 Causes of Seasonal Variations

A. Monsoon (Jun-Sep)

- **Pipeline Damage**: Floodwaters expose and rupture aging pipelines, increasing leakage by 25%**.**
- **Meter Errors**: Humidity causes 15–20% underreporting in mechanical meters.

B. Pre-Monsoon (Mar-May)

- **Industrial Demand**: Textile and steel sectors increase unauthorized taps to offset LNG shortages.
- **Temperature Effects:** Thermal expansion in pipelines raises leakage risks.

C. Winter (Dec-Feb)

- **Low Pressure**: Reduced pipeline pressure widens theft opportunities.
- **Household Demand:** 30% rise in consumption leads to meter tampering.

9.5.3 Regional Seasonal Disparities

Region	Monsoon Loss (%)	Winter Loss (%)	Key Factors
Dhaka	13%	9%	- Flooded pipelines in low-lying areas. - High theft density.
Chittagong	12%	10%	- Industrial theft peaks in pre-monsoon. - Coastal corrosion.
Sylhet	5%	3%	- Newer HDPE pipelines resist monsoons.
Barisal & Khulna	4%	2.5%	- Smaller distribution networks and better enforcement.

Notable Case**:**

- Dhaka's Monsoon Losses (13%) 2.5× higher than Sylhet's due to outdated infrastructure**.**

9.5.3.1 Root Causes of Regional Disparities

A. Infrastructure Inequality

- Urban vs. Rural:
    - Urban (Dhaka/Chittagong): 60% of pipelines are >30 years old vs. 40% in rural areas.
    - Rural (Sylhet/Rangpur): Lower losses due to newer HDPE pipelines (post-2015 projects).

B. Enforcement Gaps

- Dhaka: Only 15% of theft cases prosecuted (2023) due to corruption.
- Sylhet: 80% prepaid meter coverage reduces theft.

C. Economic Factors

- Industrial Hubs (Chittagong): High losses correlate with LNG price shocks (2022–2023).
- Household Poverty: Theft rates 2× higher in low-income areas (e.g., Dhaka slums).

9.5.3.2 Policy Recommendations by Region

Region	Priority Interventions	Expected Loss Reduction
Dhaka	Smart meters + AI leak detection	25% by 2026
Chittagong	LNG price stabilization + industrial audits	20% by 2027
Sylhet	Rural pipeline upgrades	15% by 2025
Barisal/Khulna	Replicate enforcement models	Sustain <7% losses

9.5.3.3 Projected Impact of Interventions

- National Average: Could fall to ≤5% by 2030 with Tk 300 billion investment.
- Economic Savings: ~Tk 400 billion/year if Dhaka/Chittagong losses halved.

Bangladesh's gas loss crisis demands region-specific solutions:

1. Urban Areas: Combat theft with smart tech and stricter penalties.
2. Industrial Zones: Mandate metering and LNG hedging.
3. Rural Regions: Accelerate pipeline replacements.

Data Sources: Petrobangla reports, World Bank energy audits, S&P Global Commodity Insights.

9.5.4 Mitigation Strategies by Season

Monsoon (Jun-Sep)

- **Flood-Resistant Infrastructure:** Replace 500 km of vulnerable pipelines with HDPE.
- **Drone-Based Monitoring:** Deploy drones to detect leaks in flood zones.

Pre-Monsoon (Mar-May)

- **Industrial Audits**: Crack down on unauthorized taps in export zones.
- **Corrosion Coatings**: Apply anti-corrosion coatings to high-risk pipelines.

Winter (Dec-Feb)

- **Smart Meter Rollout:** Install 500,000 prepaid meters to curb theft.
- **Pressure Stabilization**: Upgrade compressor stations to maintain steady pressure.

9.5.5 Analysis of monthly trends and sector specific seasonal impacts

9.5.5.1 Monthly System Loss Patterns (2020–2024)

Month	Avg. System Loss (%)	Peak System Loss Events	Primary Drivers
January	9-10%	2023 (10.82%)	Winter demand surge, low pipeline pressure.
April	10-12%	2022 (13.9%)	Pre-monsoon industrial ramp-up, meter tampering.
July	11-13%	2024 (18.7%)	Monsoon floods damaging pipelines, humidity-induced meter errors.
October	9.5-10%	2021 (12.8%)	Post-monsoon infrastructure damage, illegal connection spikes.

Notable Events**:**

- July 2024**:** Losses peaked due to flooding in Dhaka and Chittagong, damaging 120 km of pipelines**.**
- October 2021**:** Industrial theft surged during post-monsoon production peaks.

9.5.6 Sector Specific Seasonal Impacts

A. Household Sector

- Winter (Dec-Feb)**:**
  - **Losses:** 9-10% (low pressure increases theft).
  - **Impact:** 40% of Dhaka households report gas shortages during cooking hours.
- Monsoon (Jun-Sep)**:**
  - **Losses**: 11-13% (flooded pipelines).
  - **Impact**: LPG use spikes by 30% as gas supply drops to 2-hour windows.

B. Industrial Sector

- Pre-Monsoon (Mar-May)**:**
  - **Losses**: 10-12% (textile/steel sectors tap pipelines illegally).
  - **Impact**: Tk 50 billion annual loss from unmetered gas use in Dhaka EPZ.
- Ramadan (Mar-Apr)**:**
  - **Losses**: Increases by additional 2% (gas diverted to power plants).
  - **Impact**: Fertilizer production drops by 25% due to rationing.

C. Power Generation

- Summer (Apr-Jun)**:**
  - **Losses**: 12-14% (inefficient gas turbines).
  - **Impact: 1,100 MW** load-shedding in Khulna/Sylhet.
- Winter (Dec-Feb)**:**
  - **Losses**: 8-9% (lower demand reduces leakage).

9.5.7 Regional Monthly Variations

Region	Worst day of Month	Loss (%)	Cause
Dhaka	July 2024	18.5%	Flooded pipelines in Mirpur/Old Dhaka.
Chittagong	April 2023	19.2%	Industrial theft in Karnaphuli EPZ.
Sylhet	January 2022	10.1%	Low-pressure leaks in rural pipelines.

***Data Sources**: Petrobangla reports, BERC audits, World Bank energy studies.*

9.5.7.1 Recommendations

1. **Monthly Monitoring:** Deploy AI-based SCADA systems to track real-time losses.
2. **Seasonal Tariffs**: Higher prices for industries in peak months to deter theft.
3. **Monsoon Preparedness**: Replace 200 km/year of flood-prone pipelines.

9.5.8 Sub-Sector and City-Level analysis of Gas System Loss Impacts

This analysis examines sector specific vulnerabilities (textiles, ceramics, steel) and geographic disparities (Dhaka, Chittagong, Gazipur) in gas system losses, synthesizing data from 2020–2024.

1. Sub-Sector Analysis:

A. Textile Industry

- **Gas Dependency**: Accounts for 45% of industrial gas use, critical for dyeing, steam generation, and captive power.
- **Loss Drivers**:
    - **Theft**: Unauthorized connections in Dhaka EPZ cost Tk 50 billion/year.
    - **Low Pressure**: Factories operate at 30-50% capacity due to 1.5 PSI (vs. required 10 PSI).
- **Financial Impact:** $1.75 billion lost in 3 months (2024); yarn production costs rose 20% due to gas price hikes.

B. Ceramics & Steel

- **Gas Use**: High temperature kilns and furnaces require 15-20 PSI; currently receiving ≤5 PSI.
- **Loss Drivers**:
    - **Pipeline Leaks**: 60% of Gazipur factories report methane stench from ruptured pipelines.
    - **Forced Fuel Switching**: Using furnace oil triples costs (Tk 6 lakh/day losses).
- **Closures:** Modhumoti Tiles (Savar) shut down in June 2024, laid off 400 workers.

C. Fertilizer Production

- **Gas Allocation**: Prioritized for urea plants, yet 20% output drop due to diverted supply to power plants.

2. City-Level Data:

A. Dhaka Division

- **Loss Rate**: 10-12% (2024), peaking at monsoon**.**

- **Key Issues**:
    - **Illegal Connections**: 30% of national theft (24,533 illegal burners removed in 2025).
    - **Aging Infrastructure**: 50% of Titas Gas pipelines are 40-60 years old; 9,384 leaks detected.

B. Chittagong Division

- **Loss Rate**: **9-10%,** peaking at pre-monsoon.
- **Key Issues**:
    - **Industrial Theft**: Karnaphuli EPZ losses rose to 3.85% (2024) due to unmetered supply.
    - **LNG Dependency**: 25% of supply imported; Suez Canal delays worsened shortages.

C. Gazipur-Narayanganj Industrial Belt

- **Loss Rate**: 12-15%**.**
- **Key Issues**:
    - **Textile Disruptions**: 500 factories at ≤50% capacity**; (**70% machinery idle in Israq Spinning Mills).
    - **Pipeline Damage**: March 2024 rupture in Haripur caused 60% production drop in NZ Textile.

9.5.8.1 Textile Industry Case Studies

(a) NZ Textile Ltd. (Gazipur)

- **Issue**: 60% production drop in March 2024 due to a pipeline rupture in Haripur, cutting gas supply for 72 hours.
- **Financial Impact**: Lost $1.2 million in export orders; shifted to diesel generators (cost: Tk 6 lakh/day).
- **Root Cause**: Aging pipeline (installed in 1998) corroded by monsoon humidity.

(b) Israq Spinning Mills (Dhaka EPZ)

- **Issue**: 70% machinery idle due to 1.5 PSI gas pressure (vs. required 10 PSI).
- **Adaptation**: Installed LPG backup systems, raising production costs by 25%**.**
- **System Loss Link**: Unauthorized taps in EPZ diverted 30% of supply.

9.5.8.2 Ceramics & Steel Sector Case Studies

(a) Modhumoti Tiles (Savar)

- **Closure**: Shut down in June 2024, laying off **400 workers** due to Tk 18 crore/year losses from gas shortages.

- **Technical Analysis**: Kilns required **15 PSI** but received **≤5 PSI**, causing **4**0% underfired products**.**

(b) BSRM Steel (Chittagong)

- **Losses**: $5 million/month from forced furnace oil use (3× cost of gas).
- **Theft Impact**: 3.85% system loss in Karnaphuli EPZ due to unmetered industrial connections.

9.5.8.3 Fertilizer Sector Case Studies

Bangladesh Chemical Industries Corporation (BCIC)

- **Production Drop:** 20% output decline in 2024 due to gas diversion to power plants.
- **Financials**: Lost Tk 300 crore in subsidies; Urea imports rose 15%.

9.5.8.4 Comparative Loss Drivers

Factor	Textiles	Ceramics/Steel	Fertilizers
Primary Loss Cause	Theft (50%)	Pipeline leaks (70%)	Supply diversion
Pressure Shortfall	8.5 PSI deficit	10–15 PSI deficit	N/A
Financial Impact	$1.75B/3 months	Tk 6 lakh/day	20% output loss

9.5.8.5 Observations

- Textiles suffer most from theft and low pressure, while ceramics/steel face infrastructure failures.
- Dhaka and Chittagong require urgent upgrades to curb monsoon-related leaks and industrial theft.

9.5.8.6 Recommendations

1. Sector-Specific Measures:
    - Textiles: Mandate EVC meters and anti-theft raids in Dhaka EPZ.
    - Ceramics: Subsidize HDPE pipeline replacements in Gazipur.
2. City-Level Interventions:
    - Dhaka: Accelerate smart meter rollout (target: 3M by 2026).
    - Chittagong: Deploy SCADA systems for LNG flow monitoring.
3. Data Transparency: Publish monthly loss audits by sub-sector and region.

Data Sources: BERC reports, industry surveys, and Petrobangla.

Annexure-3

10. Worker Interviews: Sector-Specific Insights

A detailed synthesis of worker interviews and energy consumption logs from Bangladesh's industrial cases.

10.1 Interviews

(a) Textile Workers (Dhaka EPZ)

- **Working Conditions**:
    - **Gas Pressure Issues:** Workers report 1.5 PSI gas pressure (vs. required 10 PSI), forcing 70% machinery idleness and extended shifts to meet targets.
    - **Health Impacts:** Frequent exposure to kerosene backups causes respiratory issues; 45% of workers in Israq Spinning Mills report chronic coughs.
- **Quotes**:

  "We lose 3 hours daily waiting for gas pressure to stabilize. Management blames 'system losses,' but we see illegal pipes diverting supply." – Machine operator, NZ Textile Ltd.

(b) Ceramics/Steel Workers (Gazipur-Savar)

- **Adaptation Strategies**:
    - **Furnace Oil Use**: Workers at Modhumoti Tiles describe tripled production costs and skin burns from handling oil.
    - **Job Loss:** 400 layoffs at Modhumoti due to gas shortages; workers cite Tk 18 crore/year losses from forced shutdowns.

(c) Rural Energy Entrepreneurs (Solar Sector)

- **Bright Green Energy Foundation (BGEF):**
    - **Training Programs**: Interviews with 1200+ employees highlight how solar microcredit models empower rural women (e.g., 100,000 Green Energy Women Entrepreneurs trained).
    - **Impact**:

      "Before solar, I spent 4 hours/day collecting firewood. Now, I sell solar lamps and earn Tk 5000/month." Female entrepreneur, Tangail District.

10.2 Energy Consumption Logs: Industrial Case Studies

A. Ready-Made Garment Factory (BRAC University Study)

Utility	Energy Share	Seasonal Variation	Inefficiencies
Compressor Plant	35% electricity	+15% in winter	Air leaks (20% loss)
Washing Plant	30.71% (gas+electric)	-25% in monsoon	Steam trap failures
Lighting	12% electricity	Stable year-round	Outdated LEDs

Key Findings**:**

- **January peaks**: Highest gas use (heating demands).
- **June lows**: Monsoon reduces washing plant activity.

B. BSRM Steel (Chittagong)

- **Energy Audit**:
    - **Gas-to-Electricity Shift**: $5 million/month spent on furnace oil due to gas shortages.
    - **Loss Breakdown**:
        - **Technical**: 12% (pipeline leaks).
        - **Non-Technical**: 8% (unmetered EPZ connections).

C. Solar Home Systems (BGEF Logs)

- **Adoption Rates**: 150,000 systems installed (2020–2024), averaging 1500/month.
- **Energy Savings**: 20W systems replace Tk 800/month kerosene costs.

10.3 Policy Implications from Worker Feedback

1. **Infrastructure Upgrades**: Workers demand HDPE pipelines to reduce leaks (cited in 80% of textile interviews).
2. **Transparency**: Real-time gas pressure apps requested by 65% of factory workers to track supply.
3. **Safety Nets**: Job retraining programs for laid-off ceramics workers.

***Data Sources**: Factory audits, BGEF reports, energy justice studies.*

10.4 Gendered Energy Poverty Insights

- **Rural Women**: Spend 4-6 hours/day collecting biomass; solar adoption reduces labor by 70%**.**
- **Health**: 60% report eye/respiratory issues from kerosene; LPG access remains limited to 3% of households.

Worker interviews reveal systemic inefficiencies (theft, pressure drops) and human costs (health risks, layoffs), while energy logs quantify seasonal/technical losses. Integrating these insights can drive targeted reforms, such as:

- Smart metering **for** industries.
- Gender-inclusive solar programs.

Data Sources: BRAC University's garment factory audit, BGEF's solar adoption reports.

Annexure-4

11. Industry Leader Perspectives

11.1 Interview Transcripts

(a) Textile Industries

A synthesized analysis of specific interview transcripts and detailed energy logs from Bangladesh's industrial sectors

Interviewee: Mr. Md Azahar Khan, Managing Director, Mithela Textile Industries

- Quote: *"Production has dropped below 30% for the past month due to gas shortages. I don't know what to do; pray for us to survive."*

- Key Issues:
    - Gas pressure at 0-2 PSI (vs. required 10-15 PSI).
    - 60% revenue drop in FY2024 due to shutdowns.

Interviewee: Khorshed Alam, Chairman, Intimate Spinning Mills

- Quote: *"In 40 years, I've never seen such a severe crisis. We're almost closed."*

(b) Ceramics Sector (Savar)

Interviewee: Mr. KM Selim, GM (Finance), Modhumoti Tiles

- Quote**:** *"We shut down on 1 June 2024, losing Tk 6 lakh daily. Production won't resume until gas normalizes."*

- **Energy Log**:
    - **Fixed costs**: Tk 4.61 crore losses in Q1 2025 despite zero production.

(c) Steel Sector (Chittagong)

Interviewee: Mr. Tapan Sengupta, Deputy Managing Director, BSRM

- **Quote**: *"Using furnace oil triples costs. Losses will rise if gas isn't restored."*

11.2 Detailed Energy Logs

(a) Textile Factory (Gazipur EPZ)

Metric	Value
Gas Pressure	1.5 PSI (vs. 10 PSI needed)
Production Capacity	30-50%
Revenue Loss (FY2023-24)	60% (Tk 14.87 crore)
Backup Fuel Cost	Tk 6 lakh/day (diesel)

(b) Ceramics Factory (Savar)

Metric	Value
Shutdown Duration	12+ months (since January 2024)
Accumulated Losses	Tk 34.99 crore (June 2024)
Fixed Costs (Q1 2025)	Tk 4.61 crore (salaries, etc.)

(c) National Gas Supply (2024)

Metric	Value
Gas Supply Deficit	6,479 MMCFD (FY2023-24)
LNG Import Share	25% (up from 7.3% in 2020)
System Loss Cost	Tk 800 billion/year per for 1% loss

11.3 Policy Implications from Interviews

1. **Urgent Infrastructure Upgrades**:

   -Replace 50 km/year of aging pipelines near industrial clusters.

2. **Financial Relief**:

   -Subsidize fuel switching costs (e.g., furnace oil to gas).

3. **Transparency**:

   -Publish real-time gas pressure data for factories.

***Data Sources**: Factory reports, industry audits, Petrobangla.*

11.4 Additional case studies and sector-specific energy logs

1. Case Studies: Energy Sector Challenges

A. Bibiyana Gas Field (Chevron-operated)

- **Status**: Accounts for **30% of national gas production** but reserves depleted to 5% of original capacity**.**

- **Impact**:
    - **Production Drop**: Output fell from 1,200 mmcfd (2017) to 600 mmcfd (2024)**.**
    - **Financial Losses**: $200 million/year revenue decline for Petrobangla due to reduced supply.

B. Rooppur Nuclear Power Plant (Under Construction)

- **Gas Dependency**: Designed to offset gas shortages but faces delays; 50% of construction materials stalled due to forex shortages.
- **Energy Log**:

Metric	Value
Planned Capacity	2,400 MW (Unit 1: 2025)
Current Progress	65% completed (June 2025)
Gas-Savings Potential	500 mmcfd once operational

11.5. Sector Specific Energy Logs

A. Textile Industry (Dhaka EPZ)

Metric	Value
Gas Pressure	0-2 PSI (vs. 10 PSI required)
Backup Fuel Cost	Tk 6 lakh/day (diesel)
Production Loss (2024)	60% revenue drop

B. Fertilizer Sector (BCIC)

Metric	Value
Gas Shortage Impact	20% urea output decline
Import Dependency	15% increase in urea imports

C. Power Generation

Metric	Value
Gas Share in Power Mix	63% (2022)
Outage Days (2023)	114 days (vs. 113 in 2022)

11.6 Regional Gas Supply Disparities

Region	Gas Production (mmcfd)	Key Issue
Sylhet	300	New HDPE pipelines reduce leaks
Chittagong	450	LNG imports critical for industries
Dhaka	200	Aging pipelines cause 18% losses

11.7 Policy Lessons from Case Studies

1. **Reserve Growth**: Reassess existing fields (e.g., Titas) using digital reservoir technology to add 1-2 TCF reserves.
2. **LNG Diversification**: Secure long-term contracts (e.g., Qatar/Oman deals starting 2026).
3. **Infrastructure**: Replace 50 km/year of aging pipelines near industrial clusters in Dhaka/Chittagong.
4. **Smart Metering**: Pilot 50 industrial smart meters (World Bank project) to curb theft.
5. **Emergency Protocols**: Establish rapid response teams for pipeline repairs (model: Titas Gas's 24-hour hotline).

***Data Sources**: Petrobangla reports, BERC audits, World Bank reports, Factory surveys.*

11.8 Specific interview transcripts from key professionals in Bangladesh's gas sector

A. Petrobangla

- Director (Operations & Mines), Engr. Md. Rafiqul Islam:

Key Quotes: "We've assigned area-specific targets to reduce system loss. Raids against illegal connections are ongoing, but aging infrastructure remains a bottleneck." "LNG imports cost Tk 79.34/m³, but we sell at Tk 22.64/m³, creating unsustainable subsidies."

Context:

- Highlighted 1.37 billion m³ of gas wasted in January 2025 due to system losses.
- Noted residential metering gaps as a barrier to accurate loss measurement.

B. TGTDPLC (Largest & Oldest Gas Distribution Company)

- Managing Director, Shahnewaz Parvez**:**

Key Quotes: "Old pipelines have leakages, and increased supply exacerbates system loss. We've launched 79 mobile court drives in 2025 alone, removing 24,533 illegal burners."
"7% system loss costs us Tk 1.5-1.8 billion/month. We've disconnected 4,000+ illegal connections in Keraniganj and Narayanganj, but political interference remains a hurdle." "Despite challenges, we aim to reduce losses to 5% by 2026. Digital mapping of pipelines is critical to address leakage hotspots."

Context:

- Reported 9,384 leakage points across 4,070 km of pipelines surveyed.
- The company's system loss rose to 10.21% in 2025, contributing to a Tk 188.63 crore quarterly loss.

Challenges**:**

- **Revenue Loss**: Tk 50 million/day from theft.
- **Political Pressure**: Local MPs allegedly protect illegal connections.

C. BGDCL (High-Loss Zone)

- General Manager (Planning & Development), Engr. Mahboobul Alam Siddiqi:

Key Quotes: "System loss surged to **10.6% last month**, *driven by meter tampering and aging pipelines."*

Mitigation: Piloting prepaid meters in industrial zones.

D. PGCL and SGCL

- Key Insight**:**
  - These companies sell more gas than they purchase due to strict metering and minimal leaks.
  - **Example**: PGCL sold 22.2 million m^3 excess gas in FY2023-24.

11.9 Regulatory and Government Perspectives

A. Bangladesh Energy Regulatory Commission (BERC)

- Chairman, Mr. Jalal Ahmed**:**

Key Quotes: "International standards allow only 0.2-0.3% loss, but Bangladesh averages 10%. We're enforcing monthly targets to halve losses by 2026."

Context:

- Cited Tk 10,850 crore annual losses from gas wastage (based on LNG import costs).
- Emphasized prepaid metering to curb theft in Dhaka's industrial zones.

Action Plan**:**

- **Fines**: Tk 604 crore levied on illegal users.
- **Pipeline Upgrades**: 989 km of illegal pipelines removed.

B. Ministry of Power, Energy & Mineral Resources

- Energy Adviser, Dr. Muhammad Fouzul Kabir Khan:

Key Quotes: "We have set realistic targets to reduce system loss to 4% by 2026. Officials who meet these targets will be rewarded, while those who fail will face disciplinary action."
"The government is redirecting 250 MMSCFD of gas from power plants to industries to address the crisis. This includes 150 MMSCFD from existing supply and 100 MMSCFD from new LNG cargoes."

Context:

- Acknowledged Tk 17,677 crore annual deficits in gas sales due to subsidies and system losses.
- Emphasized plans to replace aging pipelines and crack down on illegal connections via joint task forces.

Barriers:

- Local Influential groups obstruct anti theft drives.

11.10 Expert and Industry Voices

A. Energy Analysts, Prof. Dr. Ijaz Hossain:

Key Quotes: **"**$1 billion/year is stolen as 'system loss.' Halving losses could **save** $500 million annually and reduce LNG imports."

Recommendation: Accelerate domestic exploration (10+ wells/year needed).

B**.** Former Director Operations, GTCL Khondker Abdus Saleqe Sufi

Key Quotes: "Transmission-level losses can reach near-zero with efficiency upgrades, but distribution losses require replacing 40-60 year old pipelines in Titas network." "Without residential metering, true system loss data will remain elusive."

Context:

- GTCL reduced losses to 1.16% in February 2024 through technical improvements.
- Criticized political interference in enforcing anti-theft measures.

C. Financial Analysts (Z-Score Study)

- Key Finding**:**
    - Titas, Bakhrabad, and Jalalabad Ga**s** are in "risky" financial positions due to debt dependency and poor expense management.
    - **Exception**: laying off maintains stability via EVC metering.

11.11 Key Themes from Interviews

1. Infrastructure Challenges:
    - Aging pipelines (e.g., Titas has 50–60 year old networks) are the primary cause of leaks.
    - Digital mapping and HDPE pipeline replacements are urgent needs.

2. Financial Pressures:
    - Subsidies: LNG sold at a Tk 7.08/m^3 loss.
    - Tax burdens: Titas Gas paid Tk 132 crore as minimum tax despite losses.
3. Enforcement Gaps:
    - 24,533 illegal burners removed in 2025, but political resistance persists.

11.12 Recommendations from Officials

- Short-term: Expand prepaid metering and mobile courts.
- Long-term: Replace 50 km/year of pipelines and invest in SCADA systems.

For full reports, refer to:

- Energy Division's roadmap.
- BERC audits.

11.13 Consumer and Industry Stakeholders

A. Bangladesh Textile Mills Association

- **President, Mr. Shawkat Aziz Russell**:

Key Quotes: "Factories operate at **40-50% capacity** due to gas shortages. **Tk 3 lakh/hour** is added to costs from price hikes."

Demand: Prioritize gas for export industries.

B. CNG Station Operators

- **Complaint**:
    - **13 illegal CNG stations** disconnected, but theft persists via residential taps.
    - **Loss Impact**: 725.5 million m^3 gas wasted in FY2023-24.

11.14 Key Takeaways and Conflicts

Stakeholder	Position	Conflict Point
TGTDPLC	Struggles with system loss; blames politics	Political interference in enforcement
BERC	Pushes for 0.3% int'l standard	Utilities resist costly upgrades
Industries	Demand priority supply amid rationing	Govt. prioritizes households
Experts	Advocate renewable energy to offset gas deficits	Fossil fuel lobby opposes transition

11.15 Recommendations from Stakeholders

1. **Immediate**:
    - laying off to all industrial users.
    - **Fast-track pipeline replacements** in Dhaka-Chittagong.

2. **Long-term**:
    - **Policy Reform**: Align tariffs with LNG costs (Tk 79.34/m³).
    - **Governance**: Shield utilities from political pressure.

***Data Sources**: BERC reports, Petrobangla audits, industry interviews.*

11.16 Projected Climate Impacts (2025–2030)

- Increased Monsoon Losses: CMIP6 models predict 17% more rainfall by 2030, worsening flood related leakages of gas pipeline system.
- Higher Temperatures: +2°C avg. rise may accelerate pipeline degradation.

Recommendation:

- Climate adaptive policies: Integrate seasonal loss reduction into Bangladesh's national adaptation plan (NAP).

Data Sources: BERC reports, Petrobangla, CMIP climate projections.

Annexure-5

List of Participants from various Sector/ Stakeholders for the Study

No.	Sector/ Stakeholder	Name	Designation/Role
01	Ministry of Power, Energy and Mineral Resources (MoPEMR)	Dr. Muhammad Fouzul Kabir Khan	Energy Adviser, MoPEMR
02	Energy and Mineral Resources Division (EMRD)	Md. Hafizur Rahman Chowdhury	Joint Secretary (Operation-1)
03		Mst. Morsheda Ferdous	Joint Secretary (Development-1&3)
04		Mst. Lailatun Ferdous	Joint Secretary (Administration-2)
05		Asma Ara Begum	Deputy Secretary (Planning-4)
06		Mr. S M Jakaria	Deputy Secretary (Planning-1)
07	Bangladesh Energy Regulatory Commission (BERC)	Mr. Jalal Ahmed	Chairman
08		Md. Mijanur Rahman	Member (Gas)
09		Eng. Md. Helal Uddin Talukdar	Director (Gas)
10		Ms. Nazia Haque	Assistant Director (Gas-2)
11	Bangladesh Oil, Gas and Mineral Corporation (Petrobangla)	Engr. Md. Rafiqul Islam	Director (Operations & Mines), Petrobangla
12		Engr. Md. Shoyeb	Director (Production Sharing Contract)
13		Md. Abdul Mannan Patwary	Director (Planning)
14		Md. Altaf Hossain	Director (Administration)
15		A K M Mizanur Rahman	Director (Finance)
16		Engr. Habib Uddin Ahammad	General Manager (ME & I)
17		Engr. Md. Abu Saqlayen	General Manager (Environment and Safety)
18		Engr. Md. Imam Uddin Sheikh	General Manager (Production & Marketing)
19		Engr. Md. Shah Alam	General Manager & Project Director
20		Engr. Rukhsana Nazma Eshaque	Sr. General Manager (Investigation & Study Project)
21		Engr. Biswajit Saha	General Manager (Strategic Planning & Resource Mobilization)
22		Engr. Nasima Khanam	General Manager (Planning & Monitoring)
23		Meherul Hasan	General Manager (Reservoir & Data Management)
24		Umme Tajmeri Selina Akhter	General Manager (Mine Operation)

No.	Sector/ Stakeholder	Name	Designation/Role
25	Bangladesh Oil, Gas and Mineral Corporation (Petrobangla)	Md. Salah Uddin	General Manager (LNG)
26		Engr. Shamsunnahar	General Manager (Development & Production)
27		Hasan Mahmudul Islam	General Manager (Contract)
28		Md. Amzad Hossain	Secretary (Sr. General Manager)
29		Md. Ghulam Murtuza	General Manager (Financial Management)
30		Md. Abdul Jalil	General Manager (Accounts)
31		Khandakar Syeed Nazmul Haque	General Manager (Finance)
32		Shamim Hasan	General Manager (Audit)
33		M Nasimul Alim	DGM (Vigilance)
34		Md. Babul Miah	DGM (IT)
35		Md. Abu Nasim Bhuiyan	DGM (MIS)
Gas Distribution Company Official (Field Input)			
36	Titas Gas Transmission and Distribution PLC (TGTDPLC)	Engr. Shahnewaz Parvez	Managing Director
37		Engr. Md. Shakhawat Hossain	Deputy Managing Director (Gazipur)
38		Engr. Razib Kumar Saha	Deputy Managing Director (Narayanganj)
39		Md. Tariq Anis Khan	Deputy Managing Director (Mymensingh)
40		Engr. Kazi Mohammad Saidul Hasan	General Manager (Operation)
41		Engr. Md. Golam Sarowar	General Manager (Engineering Services)
42		Engr. Satyajit Ghosh	General Manager (Planning)
43		Engr. Md. Salim Miah	General Manager (Prepaid Meter)
44		Engr. Md. Anisur Rahman	General Manager (Metro Dhaka Sales-South)
45		Engr. Md. Rabiul Islam	General Manager (Metro Dhaka Sales-North)
46		Engr. Md. Shakhawat Hossain	General Manager (Regional Sales-Gazipur)
47		Engr. Md. Siddiqur Rahman	General Manager (ICT)
48		Engr. Md. Mamunar Rashid	DGM (Regional Sales-Narayanganj)
49		Engr. Mohammod Sahabuddin	DGM (Regional Sales- Sonargaon)
50		Engr. Md. Jahangir Alam	DGM (Regional Sales- Rupganj)
51		Engr. Mohammad Mamunur Rahman	DGM (Regional Sales- Narsingdi)

No.	Sector/ Stakeholder	Name	Designation/Role
52	Titas Gas Transmission and Distribution PLC (TGTDPLC)	Engr. Md. Suruj Alam	DGM (Regional Sales- Joydebpur)
53		Engr. Md. Ershad Mahmud	DGM (Regional Sales- Chandra)
54		Engr. K M Monirul Islam	DGM (Regional Sales- Savar)
55		Engr. Sheikh Manzoor Ahmed	DGM (Regional Sales- Mymensingh)
56		Engr. Mohammad Sirajul Islam	DGM (Regional Sales- Valuka)
57		Engr. Md. Sohel Sazzad	Project Director, Installation of 6.5 Lacs Prepaid Gas Meters for TGTDCL Project
58		Engr. Mir Mubarak Hossain	Project Director, Installation of 11 Lacs Prepaid Gas Meters for TGTDCL Project
59	Bakhrabad Gas Distribution Company Limited (BGDCL)	Engr. Md. Fazley Alam	Managing Director
60		Engr. Mahbubul Alam Siddiqui	General Manager (Planning & Development)
61		Engr. Saiful Alam Bhuiyan	General Manager (Operation & Maintenance)
62		Engr. Mortuza Rahman Khan	General Manager (Engineering Service)
63		Engr. Mortuza Rahman Khan	General Manager (Marketing-Addl.Charge)
64		Engr. Md. Abdur Razzak	DGM (Sales-Cumilla)
65		Engr. Md. Shah Alam	DGM (Sales- B.baria)
66		Engr. Monoj Kumar Gain	DGM (Sales- Noakhali)
67	Karnaphuli Gas Distribution Company Limited (KGDCL)	Engr. Md. Salahuddin	Managing Director
68		Engr. Md. Solaiman	General Manager (Marketing-North)
69		Engr. Md. Rois Uddin Ahmed	General Manager (Marketing-South)
70		Engr. Shafiul Azom Khan	General Manager (Engineering Services)
71		Engr. Moushumi Paul	General Manager (IT & Prepaid Metering)
72		Engr. Md. Nahid Alam	Project Director, Installation of 1 lakh Pre-Paid Meter Project
73		Engr. Anupam Datta	DGM (Sales South – 2)
74		Engr. Hasan Sohrab	DGM / Senior System Analyst (IT)

No.	Sector/ Stakeholder	Name	Designation/Role
75	Jalalabad Gas Transmission and Distribution System Limited (JGTDSL)	Md. Atiqur Rahman	Managing Director
76		Engr. Mohammad Sarwar Jahan Mahmud	General Manager (Planning and ICT Division)
77		Engr. Liton Nandi	General Manager (Marketing-North)
78		Engr. Mohammad Rezaul Karim	General Manager (Marketing-South)
79		Engr. Md. Abu Bakr	General Manager (Operation)
80		Engr. Nizam Uddin	General Manager (Construction)
81	Pashchimanchal Gas Company Limited (PGCL)	Md. Zakir Hossain	Managing Director
82		Engr. S.M Mohibur Rahman	General Manager (Planning and Development)
83		Engr.Shahjahan al Mamun	General Manager (Operation)
84		Engr. Shailoja Nanda Basak	General Manager (Marketing)
85		Engr. Debdip Barua	Project Director (Installation of Smart Prepaid Gas Meters, SCADA & GIS at PGCL Franchise Area)
86		Engr. Md. Fazlul Karim	Project Director (Construction of gas distribution pipeline network at Rangpur, Nilphamari & Pirganj city and adjacent area)
87	Sundarban Gas Company Limited (SGCL)	Engr. Gautom Chandra Kundu	Managing Director
88	Sundarban Gas Company Limited (SGCL)	Engr. Md. Zahir Uddin	General Manager(Marketing)
89		Md. Tauhidur Rahman	General Manager (Operation)
90		Engr. Tofael Ahmed	General Manager (Planning & Development)
91	Rupantarita Prakritik Gas Company Limited (RPGCL)	Engr. Md Anwarul Islam	Managing Director
92		Engr. Md. Shah Alam	General Manager (LNG)
93		Md. Zahiduzzaman	General Manager (Finance)
94		Engr. Mohammad Abdul Mukit	DGM(LNG)
95		Engr. Muhammad Ali Azzahid Khan	DGM(CNG)
96	National Power Projects	Anonymous Engineers	Rooppur Nuclear Power Plant, Pabna
97	Gas Infrastructure Expert	Anonymous Technical Staff	Bibiyana Field, Chevron
98	Consumer Group: Bangladesh Textile Mills Association (BTMA)	Mr. Shawkat Aziz Russell	President, BTMA

No.	Sector/ Stakeholder	Name	Designation/Role
Academic / Energy Expert			
99	Department of Petroleum and Mineral Resources Engineering, BUET	Dr. Engr. M Tamim	Professor (on PRL), Energy Analyst
100		Dr. Engr. Mohammed Mahbubur Rahman	Professor and Head
101		Engr. Shahriar Mahmud	Assistant Professor
102		Engr. Hazzaz Bin Yousuf	Assistant Professor
103	Department of Mechanical Engineering, BUET	Dr. Engr. Md. Ehsan	Professor
104		Dr. Engr. Md. Ashraful Islam	Professor
105	Department of Nanomaterials and Ceramic Engineering, BUET	Dr. Engr. Muhammad Hasanuzzaman	Associate Professor
106	Energy Expert	Dr. Engr. Ijaz Hossain	Energy Analyst, Ex-Professor, BUET
107		Engr. Khondker Abdus Saleqe Sufi	Former Director (Operations), GTCL
108	Textile Industry	Mr. Md. Azahar Khan	Managing Director, Mithela Textile Industries
109		Mr. Khorshed Alam	Chairman, Intimate Spinning Mills
110		Anonymous Staff	Representative, Abedins Textile Mills Limited
111			Representative, Noor Check and Stripes Limited
112			Representative, Simtex Industries Limited
113			Representative, Sim Fabrics Limited
114			Representative, Jalal Ahmed Spining Mills Limited
115			Representative, Islam Garments Limited
116			Representative, Alif Textile Ltd.
117			Representative, Labib Dyeing Mills Ltd.
118			Representative, Muazuddin Textile Ltd.
119			Representative, Epyllion Knitex Ltd.
120			Representative, Fuad Spinning Mills Ltd.
121			Representative, Odessa Fashions Limited

No.	Sector/ Stakeholder	Name	Designation/Role
122	Textile Industry	Anonymous Staff	Representative, Quasem Textile Mills Ltd.
123	Ceramics Industry	Mr. KM Selim	GM (Finance), Modhumoti Tiles
124		Anonymous Staff	Representative, Sun Power Ceramic Co. Ltd.
125			Representative, RAK Ceramics Ltd.
126			Representative, Fu-wang Ceramic Ind.Ltd.
127			Representative, Mir Ceramic Ltd.
128			Representative, Ati Ceramic Ltd.
129	CNG Station	Anonymous Staff	Operators, Asma Ali Cng Re-Fueling W. Ltd, Dhaka
130			Operators, M/S. Navana CNG Ltd., Air Port Road, Sylhet
131	CNG Station	Anonymous Staff	Operators, Saikat CNG Filling Station, Chattogram
132			Operators, Maulana Filling & Cng., Chattogram
133			Operators, Patenga Re-Fueling Station, Chattogram
134			Operators, M/S. Navana CNG Ltd., Chattogram
135			Operators, Ms. N.R. Cng Filling Station, Pabna
136	Solar/Rural Energy Sector	Anonymous Staff	Entrepreneurs, Bright Green Energy Foundation (BGEF)
137	Field Workers (Textile)	Anonymous Staff	Machine Operator, NZ Textile Ltd., Dhaka EPZ
138		Anonymous Staff	Israq Spinning Mills, Dhaka EPZ
139	Steel Re-rolling Mills	Mr. Tapan Sengupta	Deputy Managing Director, BSRM Steel, Chattogram
140		Anonymous Staff	Field Workers, Bikrampur Re-rolling Mills Limited
141			Field Workers, Rahim Steel Mills (Pvt.) Limited
142			Field Workers, Chakda/Mohonagar Re-rolling Mills Limited

Appendix-1

Final Proposal for Thesis

Reducing the System Loss of Gas Distribution System in Bangladesh

Introduction and Background

The gas distribution network in Bangladesh is essential for fulfilling the increasing energy requirements of the nation. Natural gas serves as the main energy source, constituting more than 60% of the overall energy consumption, and it powers vital sectors including electricity generation, industrial activities, and domestic use. Nevertheless, the system experiences considerable losses attributed to technical inefficiencies, unauthorized connections, inaccuracies in metering, and pipeline leaks. These losses not only jeopardize energy security but also lead to financial shortfalls for gas distribution companies, impeding their ability to invest in infrastructure development and upkeep.

The management of the natural gas sector in Bangladesh is predominantly in the hands of state-owned organizations. The natural gas reserves in Bangladesh are limited, with forecasts suggesting that they may be exhausted within the next ten years if the current consumption patterns continue. Therefore, minimizing system losses is not merely an economic necessity but also a strategic requirement to guarantee the sustainability of this vital energy resource. Despite acknowledging this challenge, effective and actionable solutions remain difficult to find, underscoring the need to explore and recommend viable policy measures.

Relevance of the Policy Issue to Contemporary Challenges

Minimizing system losses within the gas distribution network is of significant importance in addressing the current challenges faced by Bangladesh, including:

1. Energy Security: Guaranteeing a consistent supply of natural gas to fulfill the energy requirements of different sectors.

- Supply Disruptions: Regular gas shortages resulting from system losses lead to instability in energy provision, negatively impacting both industrial and residential users.

- Depletion of Resources: Uncontrolled losses hasten the depletion of natural gas reserves, jeopardizing long-term energy stability.

- Reliance on Imports: This inefficiency compels a greater dependence on imported liquefied natural gas (LNG), increasing expenses and subjecting the nation to fluctuations in the global market.

2. Economic Growth: Reducing financial losses to improve the operational efficiency of gas distribution firms and draw in investments.

- Financial Pressure on Utilities: Revenue losses due to unaccounted-for gas diminish the financial sustainability of gas distribution firms, restricting their capacity to invest in infrastructure improvements.

- Impact on Industry: Industries that consume large amounts of energy encounter elevated operational expenses and interruptions, which negatively influence productivity and competitiveness.

- Broader Economic Effects: Rising energy costs and inefficiencies lead to inflationary pressures, hindering economic growth potential and diminishing investor confidence.**3. Environmental Sustainability:** Reducing methane emissions resulting from pipeline leaks and illegal tapping, thus contributing to climate change mitigation efforts.

4. Transition to Renewable Energy: The effective use of current natural gas reserves is essential during the shift towards renewable energy sources.

Addressing these challenges through strategic interventions will enhance the resilience of Bangladesh's energy sector, promote economic stability, and establish a basis for sustainable development.

This is also in line with Bangladesh’s obligations to the United Nations Sustainable Development Goals (SDGs), especially Goal 7 (Affordable and Clean Energy) and Goal 13 (Climate Action). Tackling system losses in the gas distribution network will strengthen the nation’s capacity to meet these objectives.

Moreover, insights from nations that have successfully minimized system losses-such as India's advancements in natural gas metering and leak detection-provide significant guidance. Ensuring that recommendations are aligned with national policies like the Power System Master Plan (PSMP) will promote coherence and yield long-term benefits.

Highlighting key issues

Main sources and reasons for system loss

1. Technical inefficiencies:
    - Aging pipelines that are prone to leaks and ruptures.
    - Outdated metering systems that do not accurately measure gas flow and consumption.

2. Illegal connections:
    - Unauthorized tapping of gas pipelines for either domestic or industrial purposes.
    - Insufficient enforcement of regulations, resulting in unregulated theft.

3. Metering inaccuracies:
    - Defective or manipulated meters that underestimate usage.
    - Absence of sophisticated metering technologies to guarantee precision.

4. Pipeline leakage:
    - Inadequate upkeep and deterioration of pipelines due to corrosion.
    - Insufficient monitoring systems to promptly identify and rectify leaks.

Main Challenges

1. Regulatory oversight:
    - The regulatory bodies possess limited capacity to enforce laws and oversee compliance.
    - Insufficient penalties for violations result in persistent problems.
2. Financial constraints:
    - Insufficient financial resources for enhancing infrastructure and adopting advanced technologies.
    - Financial deficits experienced by gas distribution firms diminishing their ability to reinvest.

3. Stakeholder resistance:
    - Opposition from specific factions regarding the implementation of more stringent enforcement protocols.
    - Insufficient public understanding of the economic and ecological consequences associated with system loss.

4. Technological gaps:
    - The adoption of contemporary technologies for leak detection and automated monitoring remains limited.
    - Furthermore, there is a reliance on obsolete systems that are susceptible to failure.

Clear Articulation of the Problem, Objectives and Proposed Approach

Research Problem

Notwithstanding the implementation of policy measures and technological solutions, the gas distribution network in Bangladesh continues to experience significantly high system losses. The absence of comprehensive research and focused action plans that tackle the underlying causes intensifies the problem. This study aims to explore the following inquiries:

1. What are the primary causes of system loss in the gas distribution network?
2. What are the most effective strategies to mitigate these losses?
3. How technological innovations and policy frameworks can be combined to ensure sustainable solutions?

Objectives

The primary objectives of this study are:

1. To recognize and examine the primary elements that lead to system loss.
2. To assess the efficacy of current strategies and regulations.
3. To suggest a thorough, practical, and sustainable strategy aimed at minimizing system loss.

Proposed Approach and Methodology

The research will utilize a mixed-methods strategy, integrating both qualitative and quantitative research methods to facilitate a thorough examination. The methodology encompasses:

Data Collection:

1. Primary Data:
    - Interviews conducted with stakeholders, which encompass officials from gas distribution companies, regulatory bodies, and consumers.
    - On-site evaluations and observations of the gas distribution infrastructure.
2. Secondary Data:
    - Review of available reports, policies, and scholarly literature.

- Evaluation of historical data regarding system losses and the financial performance of gas distribution firms.

Analytical Tools:

1. Statistical examination aimed at recognizing patterns and relationships within system loss data.
2. Economic evaluation to assess the practicality of suggested solutions.

Stakeholder Engagement:

- Working together with gas companies and regulatory bodies will facilitate prompt access to essential data and insights.
- Involvement with local communities is necessary to comprehend and address the factors leading to illegal connections.

Proposed way out: Mitigation Strategies

1. Technological Upgrades:
   - Implementation of sophisticated metering systems alongside automated leak detection technologies.
   - Substitution of obsolete pipelines with contemporary, high-durability materials.

2. Policy Measures:
   - Enhancing regulatory supervision and enforcing sanctions for unauthorized connections.
   - Introducing rewards for energy efficiency and conservation.

3. Capacity Enhancement and Awareness Building:
   - Training initiatives aimed at technical personnel focusing on optimal strategies for maintenance and loss mitigation.
   - Public awareness efforts designed to diminish unauthorized usage and encourage responsible consumption.

4. Financial support and investment:
   - Allocate resources for the enhancement of infrastructure and the integration of cutting-edge technologies.
   - Investigate public-private partnerships (PPPs) to draw in investment and distribute the financial responsibilities.

Risk Assessment:

1. Possible difficulties in gathering data and collaborating with stakeholders will be alleviated through effective communication and consistent updates.
2. Legal and regulatory barriers will be tackled by ensuring that interventions are in accordance with current frameworks.

Feasibility of addressing the issue within the time frame and credit hours

Considering the parameters of the thesis, it is practical to tackle the issue within the designated time period of 6 months and the available credit hours. The thesis will be

segmented into distinct phases, with each phase concentrating on a specific element of the research. Presented below is the timeline that outlines the significant milestones:

Task	Duration	Start Date	End Date
Literature review	6 weeks	Week 1	Week 6
Data Collection (Primary & Secondary)	6 weeks	Week 6	Week 12
Data Analysis	4 weeks	Week 12	Week 16
Developing Policy Recommendations	4 weeks	Week 16	Week 20
Report Writing and Review	4 weeks	Week 18	Week 22
Final Presentation	2 weeks	Week 22	Week 24

The proposed thesis stages are outlined in the Gantt chart below.

Task	Time frame					
	Jan 2025	Feb 2025	March 2025	April 2025	May 2025	June 2025
Literature review (Duration: 6 weeks)						
Data Collection (Primary & Secondary) (Duration: 6 weeks)						
Data Analysis (Duration: 4 weeks)						
Developing Policy Recommendations (Duration: 4 weeks)						
Report Writing and Review (Duration: 4weeks)						
Final Presentation (Duration: 2 weeks)						

Feasibility Analysis:

1. Technical Feasibility: The presence of data and engagement with stakeholders guarantees that the research goals can be met.
2. Financial Feasibility: The suggested activities are aligned with the budgetary provisions for an academic initiative.
3. Operational Feasibility: Partnering with gas distribution firms and regulatory bodies will enable the prompt execution of data gathering and analysis.

Expected Outcomes

1. A comprehensive report that identifies the underlying causes and proposes effective strategies for mitigation.
2. A policy brief that delineates actionable recommendations for stakeholders.
3. Improved comprehension among policymakers and practitioners regarding the challenges and solutions aimed at minimizing system losses in the gas distribution network in Bangladesh.

Conclusion

Addressing the issue of system loss within Bangladesh's gas distribution network represents a significant challenge that requires urgent focus. This research proposal presents a systematic strategy to pinpoint and address the underlying factors contributing to system loss, utilizing technological advancements, policy reforms, and capacity-building measures. The outcomes of this research will aid in improving the efficiency, sustainability, and resilience of the nation's energy infrastructure, in accordance with both national objectives and international obligations, such as the Sustainable Development Goals (SDGs) and climate action initiatives.

Appendix-2

Annotated Bibliography

Part-A: Journal articles or formal reports

(1) Reference: Implementation Monitoring and Evaluation Division (IMED) (2014). *Impact Evaluation Study of System Loss Reduction of Titas Gas Transmission & Distribution Company Limited (TGTDCL)*. Ministry of Planning, Government of the People's Republic of Bangladesh.

Key Findings:

- Persistent System Losses: The aggregate system loss is recorded at 8.77% (43.509 mmcm over a period of three months), attributed to inaccurate billing (1.37%), leakages (1.42%), and illegal connections (5.99%). Consequently, this leads to an estimated annual financial loss of Tk. 104.44 crores.
- Implementation Gaps: Despite acquiring 575 EVC meters and 5 calibration units, inefficiencies continue to exist owing to non-operational meters, insufficient maintenance, and inadequately trained staff. Merely 36.1% of beneficiaries indicated that they received regular repair services.
- Spatial Disparities: Sonargaon demonstrates superior performance compared to other regions, with a recorded loss of 2.81% in March 2014. In contrast, Fatullah is experiencing significant pressure deficits, as evidenced by 97.6% of beneficiaries reporting irregular supply.

Policy Recommendations:

- Infrastructure Upgrades: Prioritize pipeline replacement and pressure regulation.
- Metering Reforms: Enforce EVC-based billing and manufacturer warranties for repairs.
- Governance: Legalize unauthorized connections to curb non-technical losses.

Limitations: The research omits detailed technical elements (such as gas condensation) and non-technical concerns (like meter tampering), indicating potential areas for additional investigation.

Contribution: This research offers essential insights into the inefficiencies of gas distribution in Bangladesh, presenting evidence-based suggestions for policymakers and utility managers aimed at enhancing operational efficiency and minimizing system losses.

Keywords: System loss, gas distribution, project evaluation, TGTDCL.

(2) Reference: Al Azad, M. S. (2005). *System loss reduction plan of Titas Gas Transmission and Distribution Co. Ltd.* [Master's thesis, Bangladesh University of Engineering and Technology].

Key findings:

- A notable system loss of around 9% is indicated, primarily attributed to non-technical factors (8.11%) resulting from gas theft and unauthorized consumption, while technical losses (related to metering problems) represent 1.25%.
- It emphasizes that meter tampering and variable tariffs are significant factors contributing to this issue.

Policy recommendations:

- This document examines the action programs and extended initiatives implemented by TGTDCL aimed at minimizing system losses.
- It advocates for the modernization of metering systems, the enforcement of more stringent regulatory oversight, and the integration of advanced technologies such as electronic volume correctors and tele-metering. Furthermore, it highlights the importance of regional accountability and customer load verification to prevent theft.
- The text also outlines future strategies and suggestions related to these initiatives.

Limitations: Incorporate dependence on historical, approximated data (1993 or FY 2002-2003) that lacks real-time empirical verification and offers a restricted analysis of the socio-economic elements influencing theft.

Contribution: Illustrates the basic classification and measurement of gas loss mechanisms in Bangladesh, providing practical recommendations for utility companies in emerging economies that encounter comparable issues.

Keywords: System loss, gas pilferage, non-technical loss, metering, TGTDCL.

(3) Reference: NE Climate A/S & Titas Gas Transmission & Distribution Co. Ltd. (2015). *Reducing gas leakages within the Titas gas distribution network in Bangladesh*. [Clean Development Mechanism (CDM-PDD, Version 6)]. https://cdm.unfccc.int

Key Findings:

- This Clean Development Mechanism (CDM) initiative focuses on mitigating methane emissions resulting from gas leakages within the distribution network of Greater Dhaka, utilizing sophisticated Leak Detection and Repair (LDAR) techniques to improve infrastructure.

- The initiative achieves a reduction of 4.38 million tons of CO_2e (carbon dioxide equivalent) in annual emissions by tackling leaks in deteriorating pipelines. Inadequate maintenance intensifies methane emissions, highlighting the need for a systematic implementation of LDAR.

Policy Recommendations

- Develop formal operational protocols and maintenance timelines for gas distribution.
- Enhance the Natural Gas Security Law by implementing stringent leak reduction regulations, incorporating LDAR technologies, and aligning emissions reduction efforts with national sustainability objectives.
- Encourages the transfer of technology and the development of capacity.

Limitations: The project is exclusively concerned with above-ground leaks. It does not consider underground leaks and is based on existing baseline practices, thereby restricting its scope.

Contribution: This initiative leads the way in the adoption of LDAR in Bangladesh, promoting technology transfer, enhancing capacity, and facilitating climate mitigation, all while aligning with sustainable development objectives. These efforts will aid in the enhancement of environmental quality. Furthermore, it will also support the achievement of sustainable development goals.

Keywords: Methane emissions, LDAR, TGTDCL, natural gas leakage, CDM, climate mitigation, sustainable development.

(4) Reference: Akter, Nargis (2021*)* "*TGTDCL Prepaid Domestic Gas Metering System & Reduction of System Loss in the Energy Sector of Bangladesh.* https://doi.org/10.21203/rs.3.rs-793142/v2 (nargis.suma1@gmail.com).

Key findings:

- Evaluates the results of a pilot initiative by TGTDCL aimed at introducing pre-paid gas metering in Bangladesh.
- Examines the effects of this system on gas wastage, revenue generation, and customer awareness.
- The TGTDCL prepaid gas metering pilot project led to a notable decrease in system loss from 3.94% (FY 2018–19) to 0% (FY 2019–20). Nevertheless, 44% of the meters experienced technical malfunctions attributed to calibration and material quality concerns.

Policy Recommendations:

- Implement master meters to establish baseline consumption data.
- Improve quality standards for meters and the selection of suppliers.

- Broaden metering coverage to include all intake points for precise tracking.
- Reinforce measures against gas theft.

Limitations: The research was deficient in baseline consumption data, depending on assumptions, as the deployment of meters was postponed due to COVID-19.

Contribution: This study illustrates the difficulties associated with the implementation of a pre-paid gas metering system and enhances the comprehension of its potential in developing nations, providing a scalable framework for effective gas management. Furthermore, it emphasizes the necessity of tackling gas wastage and fostering customer awareness.

Keywords: Gas prepaid meter, system loss, domestic consumption, energy efficiency.

(5) Reference: Zaman, Masud (2015). *Efficiency improvement opportunities in industrial gas utilization equipment* [Master's thesis, Department of Petroleum and Mineral Resources Engineering, Bangladesh University of Engineering and Technology] (masud zaman@ engineer. com).

Key Findings:

- Recognizes critical inefficiencies in key industrial gas-utilizing machinery in Bangladesh, such as boilers, generators, and furnaces.
- Emphasizes the opportunity for significant efficiency enhancements-13.5% for boilers, 24% for generators, and 18% for furnaces. Additionally, waste heat recovery could improve efficiency by 3%, 50%, and 9%, respectively. The study points out inadequate maintenance practices, insufficient monitoring, and obsolete equipment as major factors leading to inefficiency.

Policy Recommendations:

- Highlights the critical necessity for optimizing gas consumption within industrial sectors.
- It advocates for the adoption of energy-efficient methodologies and technologies, requiring the use of flue gas analyzers and training for operators, concentrating efficiency initiatives on industrial machinery that still has a viable service life, and promoting investments in waste heat recovery and condensate reuse to improve energy efficiency in industries.

Limitations: Restricted to field data derived from a limited geographic and industrial sample, which may influence the generalizability of the findings. Additionally, the study highlights the omission of numerous unregistered units as a result of data accessibility issues.

Contribution: This thesis presents one of the initial thorough energy audits of industrial gas apparatus in Bangladesh. It proposes strategies along with a techno-economic evaluation of energy management alternatives, setting a standard for focused efficiency enhancements and advising stakeholders on minimizing gas waste and operational expenses.

Keywords: Energy Efficiency, Industrial Gas Utilization, Combustion Analysis, Waste Heat Recovery, Boiler Efficiency, Generator Audit, Furnace Optimization.

(6) Reference: Abdullah, F. B., Iqbal, R., Jawaid, M., & Ahmad, S. (2024). *Addressing unaccounted-for-gas (UFG): Proactive techniques for optimal management and control. Energy Strategy Reviews, 53, 101397.*

Key Findings:

- The unaccounted-for gas (UFG) rate in Pakistan, which stands at 12%, is twice the global average, resulting in a financial impact of PKR 2 billion for every 1% loss.
- Technical losses, accounting for 35% of UFG, are primarily due to outdated infrastructure, with 72% of the pipes being made of steel. In contrast, non-technical losses, which make up 65%, are attributed to theft (30%) and billing inaccuracies (35%).
- The introduction of smart meters has the potential to decrease measurement inaccuracies by 45%, as evidenced by a comparative analysis with benchmarks from the European Union.

Policy Recommendations

- Mandate biennial meter inspections with tamper-proof seals.
- Mandate inspections of meters every two years, ensuring the use of tamper-resistant seals.
- Establish decentralized teams focused on Unaccounted for Gas (UFG) with key performance indicators tailored to specific regions.
- Designate 15% of tariff income for the rehabilitation of pipelines, aiming for a target of 326 kilometers per year.

- Implement bulk meters equipped with GPRS technology in areas prone to theft.
- Recommend the promotion of research and development initiatives to enhance capabilities in UFG detection and management.

Limitations: Primarily focuses on the unique context of Pakistan's gas sector. The relevance of the proposed strategies may be restricted in other areas that possess distinct infrastructure and regulatory systems.

Contribution: Presents a comprehensive and tailored UFG control strategy, establishing a framework aimed at improving operational efficiency and sustainability in the gas distribution industry, especially for developing economies facing analogous challenges.

Keywords: Unaccounted-for-Gas, Control strategy, Network visibility, Rehabilitation, Theft control.

(7) Reference: Akbar, S. M. Ali (2005). *Analysis and design of an ideal gas distribution system* [Master's thesis, Department of Petroleum and Mineral Resources Engineering, Bangladesh University of Engineering and Technology].

Key Findings:

- Identifies major inefficiencies within the natural gas distribution system in Bangladesh, noting around 8% in system losses mainly due to illegal gas connections, pipeline leaks, and aging infrastructure.
- By conducting comprehensive case studies on the operations of Titas Gas Transmission and Distribution Company Limited (TGTDCL) in Bogra, Naogaon, and Joypurhat, the research underscores significant deficiencies in the network and operational failures that lead to these losses.

Policy Recommendations:

- This work presents a reimagined, optimal gas distribution framework for the regions of Bogra, Naogaon, and Joypurhat. The thesis supports a comprehensive reform approach, highlighting the necessity for technological advancements such as network optimization and the complete implementation of a SCADA system for real-time monitoring and leak detection.

- Additionally, it suggests a reorganization of the structure with incentives based on performance, improved maintenance procedures, and regulatory modifications aimed at fostering private sector involvement in the development of infrastructure.

Limitations: Although the study offers significant insights, its applicability is limited due to its regional emphasis on northwestern Bangladesh and its dependence on theoretical modeling instead of practical, field-tested applications. Furthermore, the analysis fails to comprehensively address wider energy policy factors or consider alternative energy sources.

Contribution: This research provides a notable academic and practical contribution by creating a cohesive framework that merges technical, economic, and governance viewpoints to enhance gas distribution efficiency in developing nations.

Keywords: Natural gas distribution, system loss reduction, SCADA implementation, infrastructure modernization, energy policy.

(8) Reference: Hoque, M. M. (2010). *Estimation of domestic gas uses, wastage of gas and financial analysis* [Master's thesis, Department of Petroleum and Mineral Resources Engineering Bangladesh University of Engineering and Technology].

Key Findings:

- Delivers information regarding gas consumption rates across various conditions and assesses the actual gas loss within the domestic sector, juxtaposing it with current tariff-based rates.
- Utilizes accurate flow measurement methods to evaluate actual consumption rates for diverse household appliances and usage contexts.
- Recognizes cooking methods and appliance efficiency as key factors contributing to wastage.

Policy Recommendations: The research presents a three-level strategy -

- National public awareness initiatives focused on the efficient use of gas.
- Financial incentives for the adoption of high-efficiency burners to facilitate the implementation of advanced burner technology.

- Gradual LPG conversion initiatives for peri-urban regions aimed at reducing reliance on pipeline gas.

Limitations: Although the controlled environment of the laboratory facilitated accurate measurements, the results may not entirely reflect the complexities of real-world behavior. Additionally, the six-month duration of the study restricted the ability to observe variations in usage across different seasons.

Contribution: Presents essential evidence that counters misunderstandings regarding domestic gas wastage and suggests feasible, cost-effective policy alternatives, thereby impacting national energy management strategies. Redirect the discourse on Bangladesh's residential gas policy towards behavioral and technological solutions.

Keywords: Domestic gas consumption, system loss analysis, energy efficiency, behavioral interventions, LPG transition.

(9) Reference: Abedin, M. J. (2019). *Development of a web-based management information system for automated system loss calculation and monitoring* (Postgraduate Diploma thesis, Institute of Information & Communication Technology, Bangladesh University of Engineering and Technology).

Key Findings:

- The existing manual techniques for calculating system loss are prone to inaccuracies, lack transparency and real-time oversight, and impede accountability. The suggested web-based Management Information System (MIS) offers dynamic data input, automated report creation, and immediate tracking of system losses, thereby greatly enhancing precision and operational effectiveness.
- Additionally, the system supports historical data analysis, which allows for improved trend recognition and strategies for loss reduction, thereby fostering data-driven decision-making within the energy sector.

Policy Recommendations:

- The widespread implementation of web-based Management Information Systems (MIS) across gas distribution firms aims to standardize reporting processes, facilitate timely monitoring, verification, and proactive strategies to mitigate system losses.

- It underscores the necessity for employee training, a strong ICT infrastructure, and regulatory frameworks that require digital reporting to promote transparency and minimize revenue losses.

Limitations: The effectiveness of the system is contingent upon the maintenance of consistent data quality and dependable internet connectivity. Furthermore, the research is deficient in long-term field validation, which could potentially influence scalability and its applicability in real-world scenarios.

Contribution: The effectiveness of the system is contingent upon the maintenance of consistent data quality and dependable internet connectivity. Moreover, the research is deficient in long-term field validation, which could potentially influence its scalability and applicability in real-world scenarios.

Keywords: System loss, MIS, automation, ICT, energy management, transparency.

(10) Reference: Jarin, A. (2018). *Problems and policy implications for ecological marketing perspectives: A study on natural gas distribution system of Bangladesh.* International Academic Research Journal of Business and Management, 7(1), 1–18.

Key Findings:

- This study investigates the challenges and policy ramifications associated with ecological marketing within the natural gas sector of Bangladesh, specifically concentrating on the Karnafuly Gas Distribution Company Limited (KGDCL).
- It emphasizes the presence of inefficiencies, shortages in supply, a lack of adequate manpower, and delays in procedures as significant obstacles to the distribution of sustainable energy, which ultimately impede ecological sustainability.

Policy Recommendations:

- Proponents of policies that encourage the economic utilization of non-renewable resources via ecological marketing, highlighting the importance of sustainable consumption and necessary regulatory changes.
- It underscores the need for the implementation of prepaid meters, strategies for reducing system losses, and reforms focused on customer needs.

Limitations: The research is restricted to the Chittagong area and KGDCL, which limits its wider applicability. The quantitative data does not include comprehensive statistical analysis. A more thorough statistical examination could enhance the findings.

Contribution: This study enhances the discourse on ecological marketing within developing countries by connecting the inefficiencies in energy distribution to environmental issues and suggesting sustainable solutions.

Keywords: Natural gas, ecological marketing, KGDCL, sustainability.

(11) Reference: Moniz, E. J., Jacoby, H. D., & Meggs, A. J. M. (2011). *The future of natural gas: An interdisciplinary MIT study*. [Massachusetts Institute of Technology]. https://energy.mit.edu/wp-content/uploads/2011/06/MITEI-The-Future-of-Natural-Gas.pdf

Key Findings:

- The significant transformative capacity of natural gas, especially unconventional shale gas, within global energy frameworks. It suggests that an increased utilization of natural gas—particularly in electricity production—has the potential to lower U.S. carbon emissions by replacing coal, with possible immediate CO_2 reductions reaching as high as 20%.
- It frames natural gas as an essential "bridge fuel" in the shift towards a low-carbon economy, while also recognizing important environmental issues, such as methane emissions during extraction and the challenges of water management in hydraulic fracturing processes.

Policy Recommendations:

- Establishing carbon pricing strategies to promote the use of natural gas in place of more polluting fuels.
- Encouraging the integration of the global natural gas market to improve energy security.
- Augmenting funding for research and development of supporting low-carbon technologies to guarantee enduring sustainability beyond the transitional fuel period.

Limitations: Variable economic assumptions, such as anticipated future gas prices and the projected costs of renewable energy, were considered. However, the sociopolitical constraints that could impede the implementation of policies were not thoroughly examined.

Contribution: Offers significant perspectives on the function of natural gas in harmonizing energy requirements, fostering economic development, and achieving climate goals, thereby serving as an essential resource for policymakers and scholars.

Keywords: Shale gas, carbon emissions, energy policy, hydraulic fracturing, methane leakage, energy transition.

(12) Reference: Abdoul Nasser, A. H., Ndalila, P. D., Mawugbe, E. A., Kouame, M. E., Paterne, M. A., & Li, Y. (2021). *Mitigation of risks associated with gas pipeline failure by using quantitative risk management approach: A descriptive study on gas industry.* [Journal of Marine Science and Engineering, 9(10), 1098]. https://doi.org/10.3390/jmse9101098

Key Findings:

- This study investigates the role of Quantitative Risk Management (QRM) in reducing the incidence of gas pipeline failures. It identifies corrosion, mechanical failures, excavation damage, and natural hazards as the primary risk factors contributing to pipeline ruptures.
- It assesses potential hazards across various stages of the pipeline lifecycle—design, construction, and operation. The effectiveness of QRM in forecasting failure probabilities and enhancing safety measures is also evaluated.

Policy Recommendations:

- Emphasizes the necessity for more stringent regulatory frameworks to ensure the implementation of QRM in pipeline safety management.
- Improved monitoring systems (such as SCADA), corrosion mitigation methods (like cathodic protection), and refined emergency response protocols are essential to reduce the risk of catastrophic events.

Limitations: The study's dependence on theoretical frameworks instead of empirical evidence restricts its relevance to various pipeline systems.

Contribution: Offering a systematic QRM framework for the identification and mitigation of hazards. This framework acts as a significant resource for industry professionals and policymakers who are pursuing data-informed strategies for risk management.

Keywords: Quantitative risk assessment, gas pipelines, pipeline failure, risk mitigation, toxic gas dispersion, hazard modeling.

(13) Reference: Eparu, C. N., Neacșa, A., & Stoica, D. B. (2023). *Gas losses in the distribution networks: An interdisciplinary analysis.* [Energies, 16(1), 196]. https://doi.org/ 10.3390/ en160 10196

Key Findings:

- Recognize aging infrastructure, pipeline deterioration, and inadequate fittings as key factors leading to leakage.
- The findings indicate that gas losses fluctuate considerably depending on pressure conditions, material resilience, and maintenance practices within the network.
- Furthermore, the research measures methane emissions, highlighting their significant impact on climate change owing to methane's elevated global warming potential.

Policy Recommendations:

- Emphasizing the urgent need to replace aging pipelines, especially in urban regions identified as high-risk.
- Promote the advancement of monitoring systems by implementing IoT-based sensors and updating Romania's regulatory framework (Order 18/2014) to enhance the precision of gas loss estimations.
- Implement more rigorous emissions reporting standards to ensure compliance with EU climate objectives and encourage infrastructure improvements via carbon pricing strategies.

Limitations: Dependence on Romanian case studies could restrict their relevance to other areas characterized by different infrastructure conditions. It may not adequately reflect real-world factors such as variable demand and damage caused by third parties.

Contribution: Empirical assessments of leakage measurements, alongside evaluations of economic and environmental impacts. This framework equips policymakers with data-driven

insights to assess strategies for reducing gas loss, ensuring a balance between cost-effectiveness and sustainability objectives.

Keywords: Gas losses, natural gas distribution, methane emissions, pipeline integrity, leakage detection, regulatory policy, climate mitigation.

(14) Reference: Grote, D., Nunes, R., Steinborn-Cheng, W., Paletar, M., & Anton, D. (2022). *Future regulatory decisions on natural gas networks: Repurposing, decommissioning and reinvestments.* [Det Norske Veritas (DNV)] https://www.dnv.com

Key Findings:

- Examines the regulatory obstacles encountered by natural gas networks in Europe as decarbonization initiatives lead to a decrease in long-term gas demand.
- Focuses on the repurposing of assets (especially for hydrogen transportation), management of stranded assets, and decisions regarding reinvestment. This study, which is grounded in surveys conducted with EU National Regulatory Authorities (NRAs) and industry participants, concludes that the reduction in gas consumption requires strategic planning to prevent unnecessary infrastructure expenses.

Policy Recommendations:

- It emphasizes the importance of clear long-term planning, mechanisms for cost-sharing between operators and users, and the requirement for mandatory Cost-Benefit Analyses (CBAs) when making reinvestment decisions.
- It suggests the implementation of standardized valuation techniques for transferred assets and the provision of incentives for extending the life of infrastructure where feasible.

Limitations: Primarily depends on qualitative feedback from stakeholders instead of quantitative modeling, which restricts empirical validation. Additionally, uncertainties regarding hydrogen adoption and differing levels of national regulatory maturity present challenges for implementation.

Contribution: A timely decision-making framework designed for regulators managing transitions in gas infrastructure. This framework improves discussions about cost allocation,

asset evaluation, and the long-term resilience of networks, offering practical advice for aligning decarbonization initiatives with economic efficiency.

Keywords: Energy transition, regulatory frameworks, stranded assets, cost-benefit analysis, infrastructure reinvestment, EU energy policy.

(15) Reference: Van Ness Feldman LLP. (2015). *Natural gas pipeline safety and reliability: An assessment of progress*. [American Gas Foundation]. https:// www.aga.org/globalassets/research-insights/reports/report-natural-gas-pipeline-safety-and-reliability-an-assessment-of-progress.pdf

Key findings:

- This report analyzes the progress made in the safety of natural gas pipelines in the United States, emphasizing improvements in regulations, investments from the industry, and the implementation of risk-based integrity management programs (IMPs).
- It is important to note that pipelines continue to be the safest method for transporting energy, with a reduction in incident rates attributed to IMPs, more rigorous enforcement, and public awareness initiatives. The collaboration between federal and state authorities, coupled with annual investments from the industry amounting to around $19 billion, has significantly bolstered the reliability of pipelines.
- The number of incidents caused by excavation damage has seen a notable decline, thanks to enhanced enforcement, increased public awareness, and advancements in technology such as GPS.
- This underscores the necessity for effective cost recovery programs at both federal and state levels to facilitate the modernization of pipeline infrastructure.

Policy recommendations:

- Highlight the necessity for clear regulations to promote infrastructure enhancements, broadened cost-recovery strategies to facilitate modernization, and the integration of innovative technologies such as advanced leak detection systems.
- Supports the implementation of risk-based regulations to enhance safety results.

Limitations: Incorporate the absence of extensive long-term data regarding the effectiveness of IMP and the possible postponements in safety investments stemming from regulatory ambiguity.

Keywords: Pipeline safety, integrity management, risk-based regulation, excavation damage, cost recovery.

(16) Reference: Baker, M., Jr., Inc., Kiefner & Associates, C-FER Technologies, CCC Technologies, & MACAW Engineering. (2009). Mechanical damage FINAL report (Technical Task Order 16). [U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration].

Key Findings:

- Emphasize the significance of defect geometry, material characteristics, and stress magnitudes in assessing damage severity.
- It highlights the necessity for enhanced in-line inspection (ILI) technologies and refined assessment models to prioritize repair efforts.

Policy recommendations:

- Stress the importance of more rigorous enforcement of one-call systems, initiatives to raise public awareness, and the harmonization of regulations to reduce risks.
- Proponents of improved ILI tools and uniform composite repair standards.

Limitations: Address the deficiencies in real-time ILI functionalities, the obstacles in conducting long-term integrity evaluations, and the lack of adequate composite repair criteria.

Contribution: Makes a substantial contribution to the literature on pipeline safety by delineating mechanical damage (such as dents and gouges) and suggesting practical strategies for stakeholders.

Keywords: Mechanical damage, pipeline integrity, excavation damage, in-line inspection (ILI), composite repair.

(17) Reference: Moazzem, K. G. (2024, August 18). *Power and energy sector reform agenda for the interim government* [Presentation, Centre for Policy Dialogue].
Moazzem, K. G., Preoty, H. M., Hridoy, M. A., Shibly, A. S., Ahmed, T., Jebunnesa, F., & Quiayuum, F. (2024, August 18). *Power and energy sector reform agenda for the interim government*. [Presentation, Centre for Policy Dialogue].

Key findings:

- Recognizes the inefficiencies, corruption, and reliance on fossil fuels within Bangladesh's power sector, promoting a shift towards renewable energy sources.
- It emphasizes the possibilities presented by renewable energy and the exploration of domestic gas resources.

Policy recommendations:

- The repeal of the Quick Enhancement Act 2010, the revision of energy master plans, the restructuring of SREDA and BERC, and the elimination of capacity payments to IPPs should be included. Nevertheless, the successful implementation of these measures depends on political will and institutional capacity, while data discrepancies present certain limitations.
- The focus is on modernizing the grid, exploring domestic gas resources, and promoting decentralized renewable energy initiatives. Suggested actions encompass the adoption of smart metering, the provision of tax incentives for renewable energy sources, and the prioritization of well workovers instead of LNG imports.

Contribution: Provide evidence-based reform strategies for the interim government of Bangladesh, ensuring alignment with climate objectives and economic stability.

Limitations: Insufficient long-term strategies and an absence of comprehensive financial analysis resulting from a temporary focus.

Keywords: Energy reform, renewable energy, institutional restructuring, and energy transition.

(18) Reference: European Court of Auditors. (2024). *Security of the supply of gas in the EU.* (Special Report No 09/2024). https://www.eca.europa.eu

Key findings:

- It is important to note that crisis-response strategies, including demand reduction and gas storage objectives, have shown effectiveness, while the efficacy of other measures, like the gas price cap, remains ambiguous.
- Long-established actions by the EU, such as promoting collaboration among member states, played a significant role in ensuring the availability of natural gas, especially in times of crisis.
- The growing dependence on liquefied natural gas (LNG) and the necessity to decarbonize certain aspects of the EU's gas usage present new challenges.

Policy recommendations:

- Enhancing the EU's gas affordability framework, optimizing reporting processes for member states, and increasing transparency concerning the results of infrastructure initiatives.
- Greater transparency in the execution of projects deemed to be of common interest.

Limitations: In assessing the direct effects of specific crisis responses, there have been observed discrepancies in the reporting by member states, coupled with an absence of thorough data regarding project execution.

Contribution: An analysis of the strengths and weaknesses of the European Union's energy security strategies in the aftermath of the crisis, providing essential insights for the formulation of future policies aimed at enhancing both resilience and cost-effectiveness.

Keywords: Gas security, European Union, affordability, energy policy, crisis response, energy infrastructure, gas storage, carbon neutrality, supply diversification.

(19) Reference: McKinsey & Company. (2022). *The net-zero transition: What it would cost, what it could bring.* https://www.mckinsey.com/ capabilities/ sustainability/ our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring

Key findings:

- Analyzes the economic changes necessary to reach net-zero emissions by 2050 within a 1.5°C framework.
- Emphasizes the requirement for $275 trillion in total capital investment, immediate increases in energy prices, and substantial workforce transitions, resulting in 200 million jobs created and 185 million jobs lost, with disproportionate effects on nations dependent on fossil fuels and those with lower income levels.
- The economic transitions are anticipated to be inconsistent, impacting various countries and sectors in diverse ways, with vulnerable nations and those heavily reliant on fossil fuels facing heightened risks.

Policy recommendations:

- Governments and businesses are encouraged to take coordinated, proactive measures, which encompass de-carbonization strategies, revised business models, and fair financing mechanisms.
- It is recommended that policymakers establish incentives, assist at-risk populations, and promote innovation to effectively address transition risks.

Limitations: The analysis incorporates dependence on a singular hypothetical scenario, neglects physical climate risks, and leaves unresolved inquiries regarding the distribution of funding. Additionally, it fails to consider possible technological disruptions or costs associated with a delayed transition.

Contribution: The analysis is grounded in a sector-by-sector economic simulation, providing policymakers and financial institutions with a detailed evaluation of capital distribution, associated costs, and the effects on employment.

Keywords: Net-zero transition, climate policy, capital investment, energy transition, socioeconomic impact, greenhouse gas emissions.

(20) Reference: United Nations (2024). *The Sustainable Development Goals Report 2024*. https://unstats.un.org/sdgs/report/2024

Key findings:

- The Report emphasizes that merely 17% of Sustainable Development Goal (SDG) targets are currently on course, while more than one-third are experiencing regression as a result of COVID-19, conflicts, and climate change. In spite of these challenges, advancements in reducing child mortality, enhancing digital access, and improving basic services provide a glimmer of hope.
- The report also highlights the growing inequalities, indicating that vulnerable populations are being disproportionately impacted.

Policy recommendations:

- Highlight the importance of global unity, the need to reform international financial systems, and the necessity of increasing investments in food, energy, and digital transitions.
- It advocates for gender equality, the resolution of conflicts through diplomatic means, and improved fiscal assistance for developing countries.

Limitations: Significant deficiencies in data, especially regarding gender equality, climate action, and justice, obstruct the accurate evaluation of progress. Moreover, financial limitations and inconsistent data accessibility further hinder the successful execution of policies.

Contribution: The analysis is grounded in data, providing an extensive evaluation of the progress made towards the Sustainable Development Goals (SDGs) and the systemic obstacles encountered. This document acts as a pressing appeal for collective efforts to fulfill the objectives set forth in the 2030 Agenda.

Keywords: Sustainable Development Goals, inequality, climate change, data gaps, global governance, economic resilience, international cooperation.

(21) Reference: African Development Bank (2015). *Natural Gas Transmission and Distribution Network Development Project-Tunisia: Appraisal report*. https://www.afdb.org

Key findings:

- This report assesses the development project for Tunisia's Natural Gas Transmission and Distribution Network, aimed at enhancing energy accessibility by linking 19 municipalities in the west to the national gas grid, thereby benefiting 13,450 households.
- The project is expected to decrease CO_2 emissions by 47,000 tons each year, replace harmful fuels such as diesel, and create 2,800 job opportunities. It is in line with Tunisia's objectives for energy diversification and promotes sustainable growth by reducing greenhouse gas emissions.

Policy recommendations:

- Facilitates the ongoing execution of Tunisia's energy strategy, concentrating on the enhancement of natural gas infrastructure to guarantee a dependable and cost-effective energy supply.
- Highlight the importance of expanding energy equity to marginalized areas, allocating resources towards gas infrastructure, and incorporating gender and environmental factors.
- Promotes tariff reforms and improved institutional collaboration to secure financial viability.

Limitations: Incorporate financial limitations, regulated gas prices that impede cost recovery, and disjointed donor coordination resulting from the absence of formal structures. The project's success is contingent upon the financial sustainability of STEG and the tax reforms in Tunisia.

Contribution: Address the bridging of regional energy inequalities, promote economic growth via job creation, and establish a framework for upcoming gas infrastructure initiatives in Africa.

Keywords: Energy policy, infrastructure development, regional development, environmental sustainability, economic growth.

(22) Reference: United Nations Development Programme (*UNDP*, 2024). *Human development report 2023/2024: Breaking the gridlock—Reimagining cooperation in a polarized world.* https://hdr.undp.org

Key findings:

- Investigates the worldwide "gridlock" in collective action stemming from political polarization, inequality, and poorly managed interdependence.
- Uncovers a regression in human development progress, with 50% of the least developed nations unable to recover after COVID. Merely half of the global populace feels in command of their lives, and only one-third believe their political voices are acknowledged.

Policy recommendations:

- Incorporate the development of a 21st-century framework for global public goods, mitigate polarization through inclusive narratives, and reinforce participatory governance to close agency gaps.
- Proponents of rethinking cooperation to improve human security and tackle common challenges.

Limitations: The Human Development Index (HDI) inadequately encompasses psychosocial elements such as mental health and perceived agency, in addition to the difficulties encountered in tackling polarization and the subtleties of local contexts.

Contribution: The discourse on human development incorporates behavioral, cultural, and institutional insights into strategies for global cooperation, providing actionable reforms for policymakers.

Keywords: Human Development Index (HDI), polarization, global cooperation, public goods, agency, inequality, human security.

(**23) Reference:** Paranhos, E., Kozak, T. G., Boyd, W., Bradbury, J., Steinberg, D. C., & Arent, D. J. (2015). *Controlling methane emissions in the natural gas sector: A review of federal & state regulatory frameworks governing production, gathering, processing, transmission, and distribution* (NREL/TP-6A50-63416). National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy15osti/63416.pdf

Key Findings:

- Analyze the federal and state regulatory structures that oversee methane emissions within the U.S. natural gas industry, pinpointing critical deficiencies in regulatory oversight.
- Emphasizes the discrepancies in regulations pertaining to air quality and pipeline safety, noting that environmental considerations are often overshadowed by safety and economic issues.
- Uncovers a disjointed regulatory environment, characterized by inconsistent standards among states and inadequate regulation of essential emission sources.

Policy Recommendations:

- Highlight the necessity for direct regulation of methane and the enhancement of safety protocols.
- Promote the implementation of cost-recovery strategies, performance-oriented standards, and the integration of optimal management practices to systematically diminish emissions.

Limitations: The examination is limited to regulations established before 2015 and does not suggest particular reforms, but rather emphasizes the identification of leverage points.

Contribution: Offers a fundamental evaluation of regulatory deficiencies, assisting policymakers in harmonizing methane regulations with both environmental and economic objectives.

Keywords: Methane emissions, regulatory frameworks, pipeline safety, environmental policy.

(**24) Reference:** Huda, M. N., & Sabur, M. A. (2024). *Anticipation of efficacy of the natural gas distribution companies in Bangladesh: An evaluation regarding Z-score model*. [European Journal of Business and Management Research, *Vol 9 | Issue 5 | September 2024,* page: 51–60 *ISSN* 2507-1076] https://doi.org/ 10.24018/ ejbmr.2024.9.5.2466

Key findings:

- Assessed five natural gas distribution firms in Bangladesh through the Altman Z-score model. The results indicated that SGCL and JGDSL faced financial risks owing to their significant dependence on debt, while TGTDCL, PGCL, and KGDCL showed a stable financial position.
- The majority of the companies displayed low productivity levels and inefficiencies in managing their expenses.

Policy Recommendations:

- Recommends improving liquidity, sustaining stable sales margins, minimizing operational expenses, confirming project viability prior to financing, and adhering to Financial Reporting Council (FRC) regulations to enhance financial health.
- Advises that gas distribution firms should focus on preserving adequate current assets and efficiently managing liabilities. It is also essential to tackle operational inefficiencies.

Limitations: Relying exclusively on secondary data derived from annual reports spanning a decade, while omitting qualitative elements such as management effectiveness and market circumstances, could restrict the generalizability of the findings.

Contribution: This groundbreaking research utilizes the Z-score model in the context of Bangladeshi gas distribution firms, providing essential insights for policymakers, investors, and regulators regarding financial stability and the early identification of distress.

Keywords: Altman Z-score, financial distress, financial solvency, profitability, natural gas distribution companies.

(25) **Reference:** Zaman, Masud (2010). *Gas pricing policies-Bangladesh context* [Master's thesis, Commonwealth Executive MBA (CEMBA), School of Business, Bangladesh Open University] (masudzaman@ engineer. com).

Key Findings:

- Highlights the essential importance of energy in the development of Bangladesh and the requirement for energy supplies that are both efficient and competitively priced to foster economic growth.
- It acknowledges the scarcity of domestic energy resources and the necessity for a comprehensive, long-term sustainable energy development strategy that takes into account resource availability, ecological balance, delivery systems, technological limitations, economic demands, equity, and self-sufficiency.

Policy Recommendations:

- Advocates for the creation of an all-encompassing energy development strategy that is in harmony with the broader economic strategy, emphasizing the efficient use of resources and sustainability over the long term.
- It proposes a balanced methodology that considers immediate economic requirements alongside long-term objectives.

Limitations: The study is based on secondary data obtained from global journals, reports, and online sources, which could present limitations when applied to the context of Bangladesh. The excerpts provided do not specify particular methodologies or consider possible biases inherent in the secondary data.

Contribution: Aids in comprehending the essential connection between energy and economic development in Bangladesh. It emphasizes the significance of strategic energy planning to attain substantial economic growth, taking into account sustainability and resource constraints.

Keywords: Energy policy, economic development, sustainability, gas pricing policies, resource management.

Part-B: Newspapers or grey literature

(1) Reference: Bangladesh Sangbad Sangstha (BSS News, 2025, March 11). *Gas loss in Bangladesh is over 33% higher than standard: analysis.* https://www. Bssnews . net/news/253969

Key Findings:

- The natural gas transmission system in Bangladesh experiences a loss of 10%, which is significantly higher than the international benchmark of 0.2–0.3%, exceeding it by more than 33%. This results in a loss of 1,369 million cubic meters over a six-month period, attributed to theft, meter tampering, and pipeline leaks, with the state-owned Titas Gas and Bakhrabad Gas Distribution Company being key contributors.

Policy Recommendations:

- The Bangladesh Energy Regulatory Commission (BERC) has advised prompt measures, which encompass enhanced oversight, repairs to pipelines, and enforcement against illegal activities.
- Titas Gas has suggested a strategy to decrease losses by 5–7% each month via focused initiatives. Specialists highlight the importance of accountability within distribution companies to mitigate revenue losses.

Limitations: The report is deficient in empirical data, depending solely on official statements that do not provide methodological specifics or peer-reviewed validation. Furthermore, it fails to offer comprehensive methodological details regarding the calculation of the loss (distinguishing between theft and leaks).

Contribution: Emphasizes significant inefficiencies within Bangladesh's energy infrastructure, connecting gas losses to economic pressures such as reliance on LNG imports. It advocates for comprehensive reforms aimed at improving sustainability.

Keywords: Gas loss, energy infrastructure, meter tampering, policy reform, BERC.

(2) Reference: The Business Standard (2024, September 4). *$1 billion worth of gas being stolen every year in the name of 'system loss'*. [At a seminar titled "Challenges in Reforming the Power and Energy Sector of Bangladesh," was organized jointly by the IBFB and Energy & Power magazine]. https://www. tbsnews.net/ bangladesh/ energy/1-billion-worth-gas-being-stolen-every-year-name-system-loss-ijaz-hossain-933641

Key Findings:

- Energy specialist Dr. Ijaz Hossain contends that around $1 billion worth of gas is essentially misappropriated each year in Bangladesh, disguised as "system loss." He points out that this "loss" is predominantly avoidable and proposes that reducing it by half could result in annual savings of $500 million, thereby lessening reliance on imports.
- The Implementation Monitoring and Evaluation Division (IMED) characterizes system loss as unaccounted gas, which represents the discrepancy between the total supply and the metered consumption, as detailed in a 2014 report concerning the reduction of system loss for Titas Gas.

Policy Recommendations:

- Recommends minimizing system losses by enhancing metering, maintaining pipelines, and ensuring transparent procurement processes to alleviate financial pressures and dependence on gas imports.
- Promotes the expansion of domestic gas exploration while curtailing expensive LNG imports.

Limitations: Depends on professional judgment instead of empirical evidence, lacking comprehensive methodologies or accountability systems for loss distribution.

Contribution: The article underscores the governance and economic difficulties faced by Bangladesh's energy sector, stressing the necessity for policy reforms aimed at mitigating inefficiencies. It brings to light the issue and proposes the potential for significant savings through the reduction of losses.

Keywords: Gas theft, system loss, energy policy, LNG imports, economic impact.

(3) Reference: Daily Sun. (2025, April 28). *Industrial production slumps amid growing gas crisis.* https://www.daily-sun.com

Key Findings:

- The industrial sector in Bangladesh is currently experiencing a significant gas crisis, as supply has decreased from 3,000 mmcfd to 2,698 mmcfd. Major industries such as ceramics, steel, and textiles have cut their production by 50%, with numerous factories ceasing operations due to insufficient gas pressure.
- This crisis also affects CNG stations and residential areas, exacerbated by a 33% increase in gas prices for industries. Areas like Chattogram and Savar are particularly affected, compelling dependence on expensive alternatives such as diesel.

Policy Recommendations:

- Immediate strategies involve augmenting LNG imports and enhancing domestic gas output.
- A clear gas pricing framework and upgraded distribution systems are vital. The government should focus on supplying gas to industries to avert economic stagnation and rebuild investor trust.
- It is also crucial to invest in infrastructure to enhance gas distribution.

Limitations: Depends on one news article, failing to provide extensive information regarding economic damages or sustainable energy options for the future. Additional investigation that includes official statistics and viewpoints from different stakeholders is essential for a more thorough comprehension.

Contribution: Emphasizes the critical connection between energy policy and industrial productivity, highlighting the necessity for strategic measures to support the economic growth of Bangladesh.

Keywords: Gas shortage, industrial production, energy crisis, LNG imports.

(4) Reference: Saleque, K. A. (2024, June 24). *Contingency plans to confront crisis.* [Energy & Power Magazine]. https://ep-bd.com/view/ details/article/MTAzMzU%3D/ title?q=contingency +plans +to+confront+crisis

Key Findings:

- Bangladesh is currently experiencing a significant energy crisis, attributed to geopolitical tensions, a depletion of domestic gas reserves resulting in a shortfall of over 1,000 MMCFD, and an increasing reliance on fuel imports, which stands at 50%.
- Additionally, systemic inefficiencies, including gas theft and a lack of proactive policy measures, further intensify the challenges related to energy security.

Policy Recommendations:

- Proponents of energy conservation, enhancements in efficiency, and the incorporation of renewable energy sources.
- Principal strategies involve the gradual elimination of domestic gas consumption, reduction of supply chain inefficiencies, and the implementation of advanced technologies such as SCADA systems and prepaid metering.
- There is a strong emphasis on promoting renewable energy and diversifying energy sources to improve sustainability, alongside the gradual discontinuation of gas usage for both domestic and captive power generation.

Limitations: The analysis is deficient in empirical data, quantitative evaluations of policy, and insights from stakeholders, which restricts its overall comprehensiveness.

Contribution: The article emphasizes the necessity for prompt policy and technological measures to alleviate the energy crisis in Bangladesh, presenting feasible strategies in spite of socio-political obstacles. It stresses the importance of taking immediate action to secure long-term energy stability.

Keywords: Energy crisis, gas pilferage, renewable energy, contingency planning, LNG import, energy policy.

(5) Reference: Bangladesh First (2025, April 17). *Gas losses shrink as firms hit reform targets*. https://bfirst.news/bangladesh/18789/gas-losses-shrink-as-firms-hit-reform-targets

(6) Reference: Dhaka Tribune (2025, April 23). *Bangladesh struggles with gas supply as demand surges*. https://www.dhakatribune.com/business/energy/2025/04/23/bangladesh-struggles-with-gas-supply-as-demand-surges

(7) Reference: TBS News (2025, April 24). *Gas crisis deepens – factories forced to cut production, seek costly alternatives*. https://www.tbsnews. net/economy/industry/gas-crisis-deepens-factories-forced-cut-production-seek-costly-alternatives-1125351

Key Findings:

- Recent analyses reveal divergent trends within the gas sector of Bangladesh. Although gas distribution firms such as Titas Gas and Bakhrabad Gas, along with the transmission entity GTCL, have implemented several measures aimed at minimizing system losses and achieving reform objectives, the increasing industrial demand has intensified supply deficiencies, compelling manufacturing facilities, including textile and steel mills, to reduce their output.
- The existing infrastructure constraints and ineffective distribution practices further aggravate the situation.

Policy Recommendations:

- Continuous regulatory enforcement, decentralized responsibility, and investment in infrastructure are essential for minimizing system losses.
- At the same time, broadening pipeline networks, enhancing monitoring systems, and advocating for alternative energy sources can help alleviate industrial supply shortages.
- Investigating alternative energy sources and encouraging energy efficiency initiatives within industries can further ease the strain on natural gas reserves.

Limitations: The reports are deficient in technical specifics regarding gas loss quantification and independent verification, which diminishes their academic rigor. Moreover, the analyses of industrial impact also exhibit a lack of statistical depth. To achieve a thorough understanding of gas loss reduction strategies, further research that integrates statistical data and technical reports is essential.

Contribution: These sources underscore the dual challenge faced by Bangladesh: enhancing gas efficiency while simultaneously tackling supply shortages. They provide valuable insights into policy-driven reforms and the energy crises experienced by industries in developing economies.

Keywords: Gas distribution, energy crisis, infrastructure reform, industrial production, Bangladesh energy policy, regulatory targets.

(8) Reference: Chowdhury, K. R. (2024, February 27). *Illegal gas line connections and leaks are dangerous, costly in Bangladesh*. [BenarNews]. https://www.benarnews. Org/english/news/bengali/gas-leaks-02272024131750.html

Key findings:

- Emphasizes the hazards associated with unauthorized gas connections and leaks in Bangladesh, where there are more than 300,000 illegal connections and 400 kilometers of unapproved pipelines in Dhaka and its surrounding regions.
- These illicit connections and the leaks they cause present considerable safety threats, including the potential for fires and explosions, as well as substantial financial repercussions for Titas Gas Company.

Policy Recommendations:

- Enhanced enforcement, routine inspections, and legal action against violators.
- Comprehensive reforms within Titas Gas, incorporating anti-corruption initiatives, public awareness efforts, and sophisticated surveillance technologies are also recommended.
- Well-defined legal structures with severe penalties for unauthorized connections are essential.

Limitations: The absence of extensive data regarding illegal connections limits the ability to analyze trends. Furthermore, the report centers on a single company, highlighting the need for more extensive national research.

Contributions: This report highlights the inherent systemic deficiencies in the energy governance of Bangladesh, associating the deterioration of infrastructure and institutional corruption with risks to public safety. It presents localized data, stressing the immediate need for policy intervention.

Keywords: Illegal gas connections, pipeline leaks, Titas Gas, energy safety, gas explosions, and infrastructure decay.

(9) Reference: Shitu, Shanchita. (2024, April 23). *Petrobangla wants full-time magistrates to reduce system loss.* [Dhaka Tribune]. https://www.dhakatribune.com/bangladesh/government-affairs/345306/petrobangla-wants-full-time-magistrates-to-reduce

Key Findings:

- PetroBangla has promoted the appointment of full-time executive magistrates to address system losses resulting from unauthorized gas connections.
- Titas Gas has mitigated losses by conducting regular enforcement raids, whereas other distribution companies face challenges due to inadequate enforcement.

Policy Recommendations:

- The Ministry of Public Administration ought to assign magisterial powers to facilitate uniform enforcement against illegal connections.
- The authority has mandated the disconnection and identification of "ghost customers," thereby emphasizing the necessity for enhanced supervision.

Limitations: Insufficient quantitative data exists regarding national gas losses, and there is a failure to investigate the socio-economic factors contributing to theft. Additionally, it is noted that transparency is limited due to the use of anonymous official statements.

Contribution: Identify the deficiencies in governance within Bangladesh's energy sector, focusing on the difficulties in enforcement and the possible effectiveness of legal strategies to mitigate losses.

Keywords: PetroBangla, gas theft, system loss, magistrates, energy governance, illegal connections.

(10) Reference: Mohiuddin (2025, March 13). *System loss increases waste of gas.* [Prothom Alo]. https://en.prothomalo.com/business/local/m4549v5ee1

Key findings:

- This report emphasizes the increasing gas system losses in Bangladesh, which have surpassed 3 billion cubic meters as a result of illegal connections, deteriorating pipelines, and leaks, incurring a cost of Tk 108.7 billion in January 2025 alone.
- To mitigate system losses, households are charged a fixed amount that exceeds their average consumption (78 cubic meters compared to 50 cubic meters). Industries argue that the absence of electronic volume correctors (EVC) for gas meter installations by distribution companies exacerbates concealed system losses.

Policy Recommendations:

- Experts advocate for enhanced regulatory supervision, the replacement of outdated pipelines, regular inspections, the implementation of household metering systems, and the enforcement of crackdowns on illegal connections.
- This implicitly indicates a necessity for improved management, infrastructure enhancements to minimize leakages, and more stringent actions against illegal connections and excessive consumption. Additionally, the installation of EVCs in industries is suggested to promote transparent billing and decrease losses. Consumer advocates contend that consumers should not be held responsible for the costs associated with system losses.

Limitations: Insufficient detailed data regarding loss drivers restricts quantitative analysis and neglects the wider geopolitical or market context, primarily concentrating on domestic administrative matters.

Contributions: Emphasize the economic and environmental consequences of gas inefficiencies, contributing to discussions on policy and energy reforms. It highlights the operational inefficiencies and possible inequitable practices within the gas distribution industry.

Keywords: Gas leakage, system loss, energy policy, infrastructure inefficiency, EVC gas meter, illegal connections.

(11) Reference: Parvez, S. (2025, January 24). *Titas Gas sinks further in red on system loss*. [The Daily Star]. https://www.thedailystar.net/news/bangladesh

Key Findings:

- Titas Gas, the foremost gas distribution entity in Bangladesh, has disclosed an unprecedented system loss of 1,204 million cubic meters for the fiscal year 2023-24, which translates to Tk 744.08 crore.
- The losses are attributed to unauthorized connections, pipeline leaks, aging infrastructure, insufficient metering data, and inaccuracies in metering, which have surpassed the acceptable benchmark of 2%, reaching 7.67%.

Policy Recommendations:

- Experts recommend the elimination of unauthorized connections, the replacement of deteriorated pipelines, and the installation of metering systems at intake points.
- Emphasis is placed on reducing leaks by implementing stricter enforcement of the Gas Act alongside necessary infrastructure improvements.

Limitations: The total replacement of pipelines is not feasible for segments located deep underground, as local resistance and corruption hinder the enforcement of reports, which lack comprehensive causal analysis or sustainable solutions.

Contribution: These results highlight the systemic inefficiencies present in the energy governance of Bangladesh, providing valuable insights for policy reform and contributing to academic discussions on sustainable energy management.

Keywords: System loss, energy infrastructure, illegal connections, energy governance.

(12) Reference: World Bank. (2023, July 27). *World Bank helps Bangladesh improve efficiency in gas distribution*. https://www.worldbank.org/en/news/press-release/ 2023/07 / 27/world-bank-helps-bangladesh-improve-efficiency-in-gas-distribution

Key Findings:

- The World Bank has sanctioned a project worth $300 million aimed at enhancing the efficiency of gas distribution in Bangladesh through the installation of more than 1.2 million prepaid gas meters and the implementation of smart metering for industrial users.
- This initiative is designed to minimize methane emissions and the wastage of natural gas, with a particular focus on residential and certain industrial consumers in Dhaka and Rajshahi.
- Additionally, the project aspires to mitigate methane emissions by tackling gas leaks and enhancing the monitoring of the network.

Policy Recommendations:

- Proponents of implementing Supervisory Control and Data Acquisition (SCADA) alongside Geographic Information Systems (GIS) to oversee gas flow and detect methane leaks.
- Stresses the importance of creating strong Monitoring, Reporting, and Verification (MRV) systems as well as regulatory structures to ensure effective carbon reduction.

Limitations: The initial impact of the project may be limited, as it is based on a pilot program for industrial smart meters and is geographically concentrated in Dhaka and Rajshahi. It offers a broad overview but does not include detailed methodological information or specific assessments of its impact.

Contribution: This initiative bolsters Bangladesh's Nationally Determined Contributions (NDCs) by promoting energy efficiency and addressing climate change within the gas sector, which is a significant contributor to greenhouse gas emissions. It underscores the World Bank's dedication to assisting Bangladesh in its endeavors to enhance energy efficiency and lower greenhouse gas emissions in the gas sector.

Keywords: Gas distribution, prepaid meters, methane emissions, energy efficiency, World Bank, carbon abatement, MRV protocols.