THE POWER EQUATION

A Comprehensive Review of NTDC

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PIDE
Pakistan Institute of Development Economics

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A COMPREHENSIVE REVIEW OF NATIONAL TRANSMISSION AND DISPATCH COMPANY LIMITED

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List of Abbreviations

ADB	Asian Development Bank
CPPA	Central Power Purchasing Agency
CTBCM	Competitive Trading Bilateral Contract Market
EMO	Economic Merit Order
HUBCO	The Hub Power Company Limited
IGCEP	Integrated Generation Capacity Expansion Plan
JICA	Japan International Cooperation Agency
LDS	Load Dispatch System
NEPRA	National Electric Power Regulatory Authority
NGC	National Grid Company
NPCC	National Power Control Centre
NTDC	National Transmission and Dispatch Company
OPGW	Optical Ground Wire
PLAC	Part Load Adjustment Charges
RLNG	Regassified Liquefied Natural Gas
RTUs	Remote Terminal Units
SCADA	Supervisory Control and Data Acquisition
LDS	Load Dispatch System
TNO	Transmission Network Operator
TSEP	Transmission System Expansion Plan

Preface

Pakistanis, for decades, have endured the frustration of flickering lights and unpredictable power cuts. This report delivers a sobering diagnosis: the National Transmission and Dispatch Company (NTDC), the backbone of our grid, is simply not up to the task.

The Problem is Clear: We have a grid riddled with inefficiencies. Overloaded lines strain the system, while underutilized infrastructure sits idle. The result? Billions in losses, unreliable power delivery, and frequent blackouts.

The Blame Lies Within: Poor planning, outdated technology, and a lack of qualified personnel plague NTDC. Their bureaucratic structure, rife with political interference and a disconnect from performance-based incentives, stifles progress.

The Way Forward is Bold: A complete overhaul is essential. We need an independent NTDC, free from political meddling, governed by a board of qualified professionals. Competent leadership, with clear performance targets tied to compensation, will drive accountability. Skilled personnel empowered to make independent decisions are crucial across all departments.

Investing in the Future: Public listing on the stock exchange can increase transparency and financial stability. Modernization, innovative thinking, and a focus on efficiency are paramount.

This report is a call to action. By addressing these critical issues, we can finally build a reliable and robust national grid. Only then can Pakistanis truly unlock the power they deserve.

We hope those in charge will recognize the urgency and act decisively to correct the course.

Dr Nadeem Ul Haque
Vice Chancellor PIDE

Executive Summary

This study reviews NTDC's performance as the national grid and system operator. A case study approach is adopted to evaluate the effectiveness of NTDC's performance. The study finds:

Key Findings

- The transformation capacity of type 500/220 kV is 25950 MVA (roughly equivalent to 25950 MW), against the installed capacity of 43749 MW—much below the satisfactory level.
- 15 (550 kV) and 39 (220 kV) transmission lines are overloaded (80% and above). On the other hand, 53 (550kV) and 65 (220kV) lines are underutilized (30% or less) – reflecting inadequate planning.
  - Overloaded lines affect reliability, and underutilized transmission infrastructure is increasing per-unit transmission costs for end-consumers.
- Transmission constraints resulted in a loss of PKR20.203 billion in FY2023.
  - Over-loaded transmission lines, inadequate transformation capacity of power transformers, and transmission line outages are a few reasons behind the under-utilization of efficient power plants.
- In FY2023, PKR 46.6 billion was paid to power plants for Part Load Adjustment Charges due to transmission and distribution constraints, which increased fuel cost adjustments for end-consumers.
  - Economic Merit Order (EMO) violations greatly influence the cost per unit for end-consumers, resulting in a financial loss of PKR 20.3 billion in FY2023.
  - EMO has not yet established specific criteria to rank take-and-pay and take-or-pay power plants differently.
- The total financial impact caused by supply loss incidents amounted to approximately PKR 11.9 billion (from FY2015 to FY2023).
  - Tower collapses have become frequent in recent years, disrupting the power supply, posing safety hazards, and jeopardizing the integrity of the entire network.
  - The system's interruption frequency has increased by 400%.
- The outdated power system mechanism is responsible for frequent blackouts in the country.
  - Overloaded transmission lines, equipment failure, poor maintenance, malfunctioning control systems, outdated communication modes, and the lack of trained staff are all responsible for blackouts and delays in restoration.

- No approved Transmission System Expansion Plan (TSEP) is available.
  - It is an important document that plays a crucial role in the systematic growth of the power sector.
- The Integrated Generation Capacity Expansion Plan (IGCEP) for 2021 and 2022 has been developed by NTDC and approved by NEPRA.
  - Deficiencies in demand forecasting have resulted in over-forecasted demand and consequent surplus in installed generation capacity, leading to a capacity payment burden for consumers.
- NTDC has sufficient funds for infrastructure upgrades and expansion – the challenge lies in its effective utilization.
- Failing to meet deadlines is causing cost overruns and delays.
  - It is due to the lack of established processes, insufficient and incompetent human resources, limited opportunities for capacity-building, and outdated software.
- NTDC lacks initiative; donor agencies have driven all recent efforts to upgrade technology and integrate renewables.
  - NTDC's increasing dependence on foreign loans is increasing financing costs (28% growth from FY2014 to FY2023), jeopardizing its future financial stability.
- The primary problem lies in its governance structure.
  - Despite being an independent organization, NTDC still operates with a bureaucratic mindset.
  - Over-staffed, BPS scales, and no performance based annual bonuses/ incentives.
  - Communication hurdles within the organization are affecting performance.
  - The presence of non-expert members and excessive government representation in the NTDC board compromises NTDC's ability to make independent decisions.
  - Politically appointed (and temporary) Managing Directors (MD).
  - Senior management is getting a market salary, but not linked to their performance.

Way Forward

The study suggests that immediate action is necessary to fix transmission network inadequacies, which are causing losses to the power sector and increasing consumer burdens. The sector needs a robust national grid to transmit power from plants to centers. For this to happen...

- NTDC requires a complete overhaul of its governance structure.
  - Decentralization of power – ensuring accountability and establishing an independent entity based on corporate principles for success.
- An independent and non-political board of professional directors.
  - The director is well-versed in the power sector, has no conflicts of interest, and can make tough decisions.
- For NTDC to succeed as an effective National Grid Company and as an effective System Operator, an unprofessional bureaucracy must stay out of their managerial and financial affairs.
- A competent and apolitical MD and senior management must be appointed for a certain period with clear targets and a market-based salary linked to the targets and the organization's profitability.
- NTDC needs competent professionals in every department.
  - Appointed on merit, empowered to act independently without any political influence, and able to make critical decisions.
- To increase equity financing and future financial stability, it is essential to have NTDC's disclosure on the stock market.

Better coordination, innovative thinking, proactive problem-solving, and efficient processes are crucial for NTDC to improve its performance.

1

Setting the Context

1. Setting the Context

After unbundling the Water and Power Development Authority (WAPDA) into distinct entities responsible for electricity generation, transmission, and distribution, the National Transmission and Dispatch Company (NTDC) was created as an independent public limited company on November 6, 1998, by the Companies Ordinance 1984 (now Companies Act 2017) with its headquarters in Lahore.

NTDC began commercial operations on March 01, 1999, after acquiring the Certificate for Commencement of Business. In December 2002, NTDC was granted an exclusive Transmission License by the National Electric Power Regulatory Authority (NEPRA) for thirty years under Section 17 of the Regulation of Generation, Transmission, and Distribution of Electric Power Act of 1997. It covers the entire country's transmission network, excluding the area served by K-Electric. NEPRA determined NTDC's first tariff in April 2004.

NTDC has taken over all the assets, resources, and liabilities of the 220 KV and above 500 KV Grid Stations and Transmission Lines/Networks formerly owned by the Pakistan Water and Power Development Authority (WAPDA). The company establishes a crucial link connecting Power Generation Units to Load Centers dispersed throughout the country, including Karachi, thereby establishing and overseeing one of the most extensive interconnected networks. It transmits power from hydroelectric power plants situated in the north and thermal units from both public (GENCOs) and private sectors (IPPs) in the south to power distribution companies using a primary Extra High Voltage (EHV) network.

In 2018, the NEPRA Act was amended to establish a legal framework for developing a competitive electricity market. According to the updated Act, the System Operator (SO) and National Grid Company (NGC) will require separate licenses. By implementing the Competitive Trading Bilateral Contract Market (CTBCM), the SO will operate independently and will be granted a separate license. Meanwhile, the NTDC will be renamed as the National Grid Company (NGC) and will no longer operate as the SO.

On August 24, 2022, NTDC applied for a system operator license, including submitting Grid Code 2023 for approval under Section 23G of the NEPRA Act. The Authority granted NTDC the System Operator License and approved the Grid Code 2023 on March 22, 2023.

Section 17 of the NEPRA Act states that the National Transmission and Dispatch Company (NTDC) has been granted a transmission license. The NEPRA Act allows only one entity, the National Grid Company (NGC), to operate at the national level at any given time. Currently, NTDC holds the status of NGC under NEPRA's license. As NGC, NTDC plays a crucial role in ensuring the smooth flow of electricity across the National Grid. The NGC is responsible for operating and providing safe, reliable transmission and interconnection services on a non-discriminatory basis, including for any Bulk Power Consumer (BPC) who wishes to connect directly to its facilities.

Section 18(A) of the NEPRA (Amendment) Act of 2018 allows Provincial Governments to construct powerhouses, grid stations, and transmission lines for intra-provincial use, eliminating the exclusivity of NTDC. The NEPRA Act also allows Provincial Governments to establish Provincial Grid Companies (PGCs) to use power within the provincial boundaries.

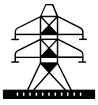
By Section 23(G) of the NEPRA Act, 2018, it is illegal for any individual to perform the duties of a System Operator unless the Authority (NEPRA) licenses them under this Act. In compliance with this regulation, NTDC applied for a license to operate as a System Operator, and after thorough examination, the Authority granted them a license on March 21, 2023. This license will remain valid for twenty years.

Box 1: Grid Code 2023

The Grid Code 2023 is an improvement over the Grid Code 2005 as it considers the new power system stakeholders introduced by the amended NEPRA Act of 2018; in alliance with the Competitive Trading Bilateral Contract Market (CTBCM) structure. It outlines a completely revamped power system planning process that follows an integrated system planning methodology. All relevant power sector entities will work with the system operator to prepare a centralized Integrated System Plan. With the increase in renewable energy power plants, the Grid Code 2023 provides more detailed information on the functioning of these plants. It covers the technical functioning of HVDC lines and introduces voltage levels beyond 500 kV. It also discusses the functions of metering and protection.

1.1. NTDC's Functions and Responsibilities

NTDC functions in various capacities, encompassing roles such as:



Transmission Network Operator (TNO)

- Operation, maintenance, planning, design, and expansion of the 500 kV and 220 kV transmission network and strengthening/upgrading of the existing one.

Wire Business

- Transmission & Generation Planning
- Design and Engineering
- Project Development and Execution
- Procurement, Operation & Maintenance of Transmission Assets

System Operator (SO)

- Arranging non-discriminatory, non-preferential economic dispatch, ensuring safe, secure, and reliable supply of electricity

System Operation and Dispatch

- Generation Dispatch
- Power System Operation and Control

As per its license, the SO is responsible for performing various tasks outlined in Section 23G of the Act. These include but are not limited to generating schedules, commitments, and dispatches; scheduling transmission and coordinating generation outages; managing transmission congestion; coordinating cross-border transmissions; procuring and scheduling ancillary services; and planning the integrated power system to ensure adequate transmission and generation capacity is available to meet the country's electricity demand (NEPRA, 2023).

NTDC's website outlines its vision to become a role model for the public sector in Pakistan by offering excellent transmission and dispatch services, which support the country's economic growth. NTDC's mission is to provide Pakistan with a reliable, efficient, and stable transmission network and dispatch services. They aim to achieve this by adopting sustainable best international practices that ensure optimal utilization of resources, meet the transmission service requirements of generators and end-users, maximize return to stakeholders, and provide a rewarding workplace for the employees.

1.2. Rationale for Evaluation

This assessment aims to review NTDC's past performance as the national grid and system operator, current practices, and future preparation as the National Grid Company (NGC) and System Operator (SO) under Grid Code 2023. The evaluation aims to analyze the effectiveness and adequacy of NTDC's functional processes, operational procedures, financial and organizational capabilities, and governance structure. The objective is to gather information to make informed decisions and identify areas for improvement.

2

Methodology

2. Methodology

A case study approach is adopted to evaluate the effectiveness of NTDC's performance. Both primary and secondary data are analyzed.

- Primary data (information) is collected from interviews (interactive sessions) with ex and current officials at NTDC, and sector experts. Representatives of almost all relevant NTDC departments are interviewed.
- Secondary data includes NTDC Annual Reports, NEPRA Transmission Performance Reports, Evaluation Reports of Various NTDC projects, and other published power sector reports/ books for Pakistan.

Thematic analysis is applied to the collected information.

Limitation: The evaluation relies only on information (both qualitative and quantitative) gathered from informal interviews/discussions and published sources; no survey is conducted.

2.1. Study Questions

- Has NTDC effectively fulfilled all its duties in accordance with the regulatory framework of Grid Code 2005 and its sub-codes? Additionally, how well-prepared is NTDC for its upcoming role as a National Grid Company under Grid Code 2023?
- How adequately is NTDC (National Grid Company) complying with transmission industry standards in terms of safety, reliability, stability, integrated operability, and efficiency of the whole or a material part of the electric power system?
- How ready is NPCC (currently under NTDC) to take on the role of an independent System Operator?
- Is the asset procurement and management processes at NTDC as per industry standards and international practices?

- How efficient is the planning process at NTDC? How is the planning process adapting to the changes introduced by Grid Code 2023?
- Is the financial management of NTDC in line with contemporary corporate business practices?
- How competent is the governance structure at NTDC in terms of executing its duties?
- Does NTDC have enough capacity (human and financial) to address systemic issues faced in the power sector and perform its functions per its objectives?
- How is NTDC revamping to align with energy transition pathways and to cope with the technological advancements in the industry?
- How can its work be made consistent with international best practices?

To answer these questions, we have divided the assessment into five parts. The first part examines NTDC's effectiveness as a transmission network operator and planner and its performance as a System Operator. This part also assesses its efficacy in procurement processes and regulatory compliance. The second part focuses on NTDC's financial security. The third section discusses NTDC's governance structure. The fourth part briefly outlines NTDC's readiness for the future, and the last part provides a roadmap for augmenting NTDC's performance.

3

Gauging NTDC'S Effectiveness and Efficiency

3.1. Transmission Network and Performance

Table 1: Transmission Infrastructure Owns and Maintains by NTDC as of June 2023

	Type	Nos	Capacity
Grid Stations	500 kV	19	
Transformers at 500kV	500/220 kV	47	25,950 MVA
Transformers at 500kV	220/132 kV	38	8150 MVA
Grid Stations	220 KV	50	
Transformers at 220kV	220/132 kV	141	37190 MVA
Transmission Lines (circuits)	500 kV	71	8825 km
Transmission Lines (circuits)	220 kV	166	11633 km
HVDC Transmission Circuits*	±660 kV	2	886 km (4800 MVA)

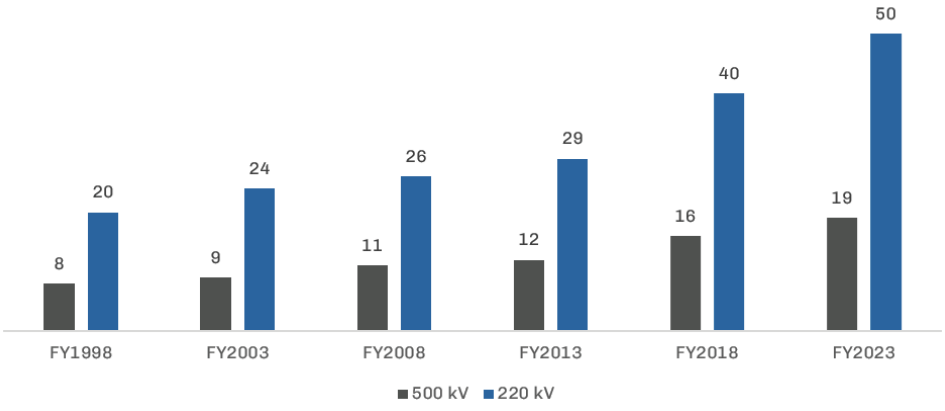
Source: NEPRA 2023 and NTDC 2021 *2022

3.1.1. Grid Stations

In examining the data pertaining to NTDC's grid stations spanning from FY1998 to FY2023, it shows a positive trend, but slow growth. In the first fifteen years after becoming an independent company (even after the Grid Code 2005), only four 500kV and nine 220kV grids were added. The upward trajectory got picked up from 2014 onwards, as seven 500kV and twenty-one 220kV grids were added to the national transmission system (Figure 1).

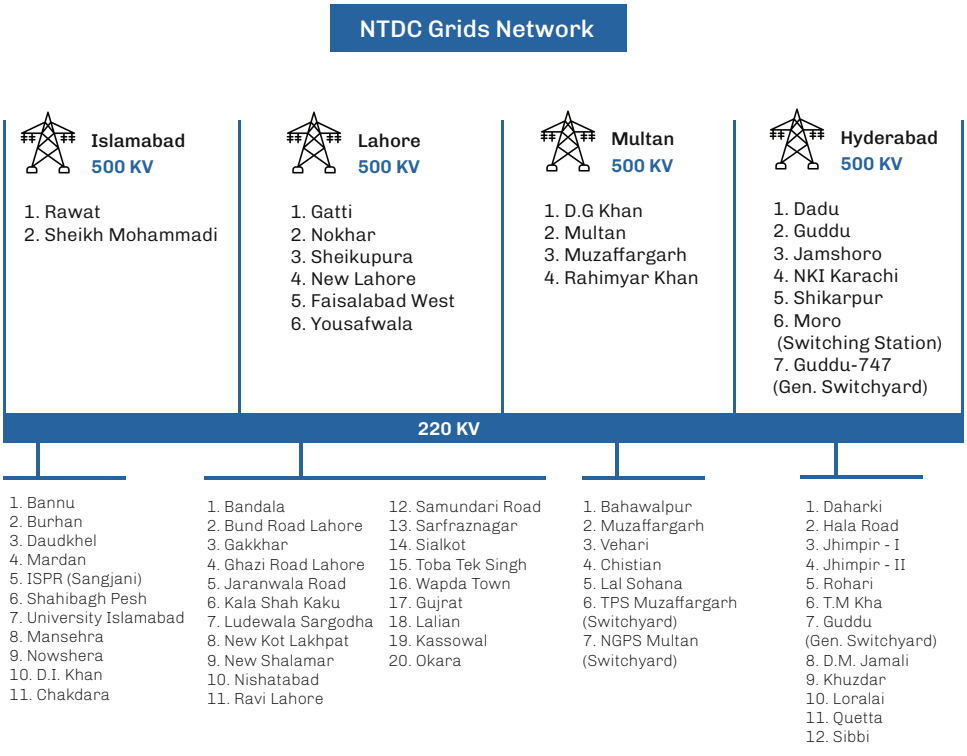
The recent expansion seems to align with NTDC's strategic vision for enhancing the capacity and reliability of the national power grid, indicative of proactive measures to meet future energy needs. The continual addition of grid stations will not only contribute to the reliability of the power transmission network but is expected to provide redundancy in the future, mitigating the risk of system failures and enhancing overall grid resilience.

Figure 1: No of Grid Stations



Source: NTDC Electricity Marketing Data, 47th Edition and NEPRA Performance Evaluation of Transmission Companies 2022-23

Figure 2: NTDC Grids Networks

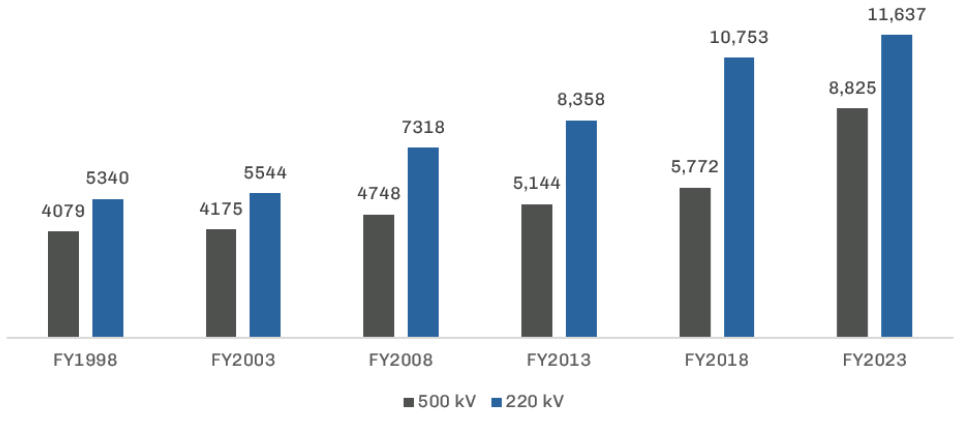


Source: NEPRA Performance Evaluation Report 2022-23

3.1.2. Transmission Lines

In the NTDC network, there has been a positive trend in the expansion of transmission lines. The growth was slow in the early years, followed by a modest increase between FY2013 and FY2018 in the 220kV transmission lines. However, the 500kV transmission lines, after a sluggish growth, have increased significantly to 8825 circuit km from 5772 circuit km in the last five years (from FY2018 to FY2023).

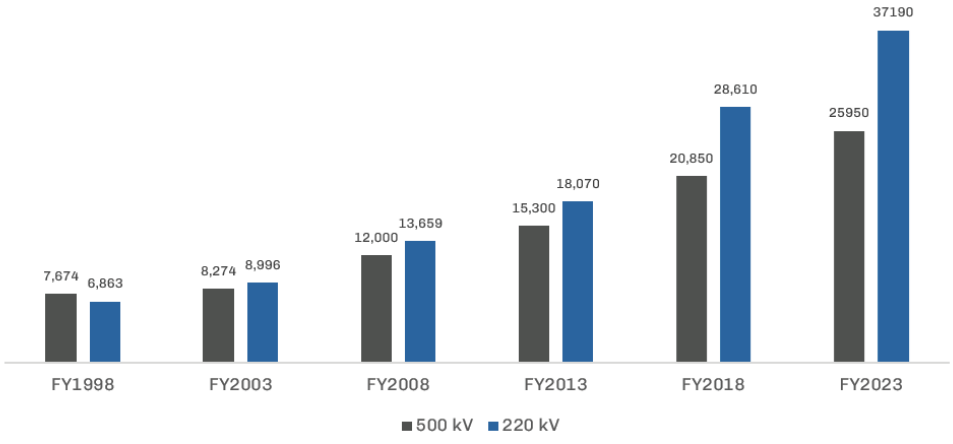
Figure 3: Transmission Lines KM Expansion



Source: NTDC Electricity Marketing Data, 47th Edition and NEPRA State of Industry Report (various Years)

The increase in transformation capacity over the years indicates that NTDC is investing in upgrading its infrastructure to handle higher volumes of electricity transmission. This upgrade is likely in response to growing electricity demand or the need to modernize aging infrastructure. By focusing on increasing capacity in 500 kW transmission lines, NTDC may be aiming to improve the efficiency of electricity transmission. Higher voltage lines typically experience lower power losses during transmission, allowing for more efficient delivery of electricity over long distances. But still, this transformation capacity is not sufficient to evacuate power and fully utilize the efficient generation plants.

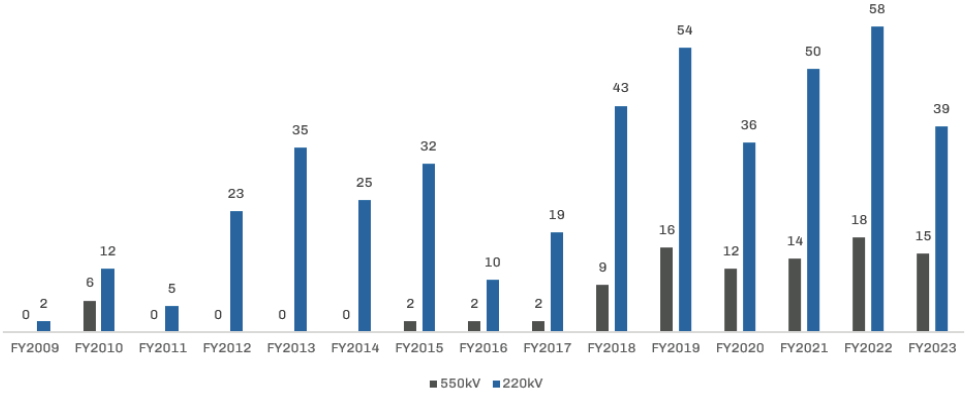
Figure 4: Grid Transformation Capacity



Source: NTDC Electricity Marketing Data, 47th Edition and NEPRA Performance Evaluation of Transmission Companies 2022-23

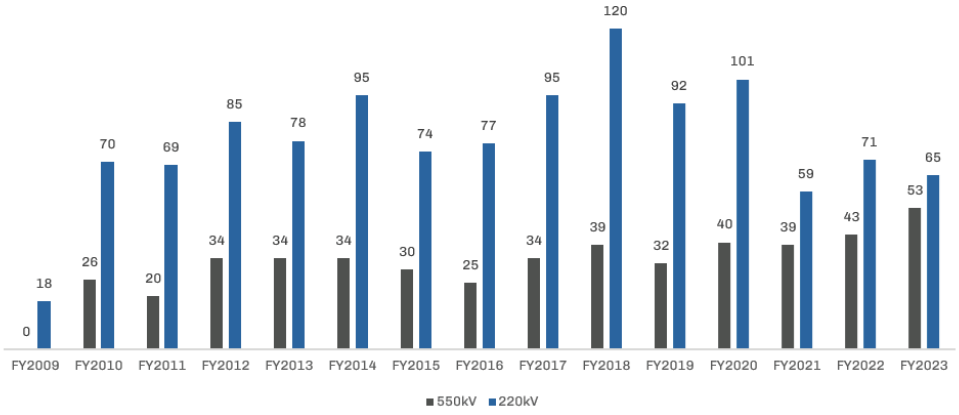
Enhancing transformation capacity in higher voltage transmission lines could also support the integration of renewable energy sources in the near future. Many renewable energy projects, such as large-scale wind or solar farms, generate electricity at voltages suitable for transmission via higher capacity lines. However, it could be the lack of effective planning that the number of underutilized transmission lines as well as overloaded transmission lines are increasing.

Figure 5: Overloaded Transmission Lines (No.) > 80%



Source: NEPRA State of Industry Reports (Various Years)

Figure 6: Underutilized Transmission Lines (No.) < 30%



Source: NEPRA State of Industry Reports (Various Years)

The underutilization of resources within NTDC suggests inefficiency in the company's operations. When valuable assets remain unused, it hinders the company's ability to allocate resources optimally. This can impede investments in essential upgrades and expansions, eventually stalling progress. Moreover, when transmission infrastructure is not fully utilized, the fixed costs associated with its maintenance and operations are spread across a reduced volume of transmitted electricity, increasing per-unit transmission costs for end-consumers.[1] Whereas, when the power grid is overloaded, there's a higher chance of system failures and blackouts. The equipment is designed to operate within specific load limits, and exceeding them can cause overheating, voltage instability, and equipment failure.

Expanding the transmission line network can significantly improve the electrical grid's reliability and resilience. A more extensive transmission line network makes power distribution more efficient, reducing the chances of blackouts caused by equipment failures or overloads. Moreover, having multiple transmission pathways will provide redundancy, which will help minimize the impact of any disruption in any particular area. However, assessing whether expanding transmission lines would result in better access to remote areas or create more demand in specific locations is crucial. This is reflected in Figure 5 and Figure 6. Despite receiving expensive loans (details in Section 4), the NTDC has not significantly improved its performance.

A robust transmission system is vital for continuous electricity supply and access to power from the most efficient plants, as per the Economic Merit Order (EMO). In the NTDC system, efficient power plants remained underutilized due to transmission constraints. According to the Grid Code, NTDC is responsible for establishing a planning process that results in recommendations for specific transmission system reinforcements, up-gradation, and expansion projects.

Since 2015, several new power plants, both conventional and renewable fuel, have been introduced. However, in many cases, the interconnection arrangements for evacuating power from various power plants have not been put in place in a timely manner, leading to financial losses. NTDC failed to complete dispersal arrangements on time and within budget.

For instance, wind power plants (WPPs) in Jhampir and Gharo; in the Southern network, the interconnection of 1,320 MW China Power Hub Power Company Limited (CPHGCL) plant; in the North, the 147 MW Patrind Hydropower Project, were not completed according to the given design and timeline (NEPRA, 2020). Likewise, during FY2023, NTDC couldn't finish the transmission line for evacuating power from the Thar Coal Block-I Power Generation Company's 1320 MW project. Consequently, power from less expensive Thar Coal Block-II projects was curtailed temporarily (NEPRA, 2023).

Not evacuating power from the available WPPs, qualifies them for payments against Non-Project Missed Volume (NPMV), which is an undesirable financial burden against energy that is never absorbed in the system but reflected in the consumer-end price of electricity.

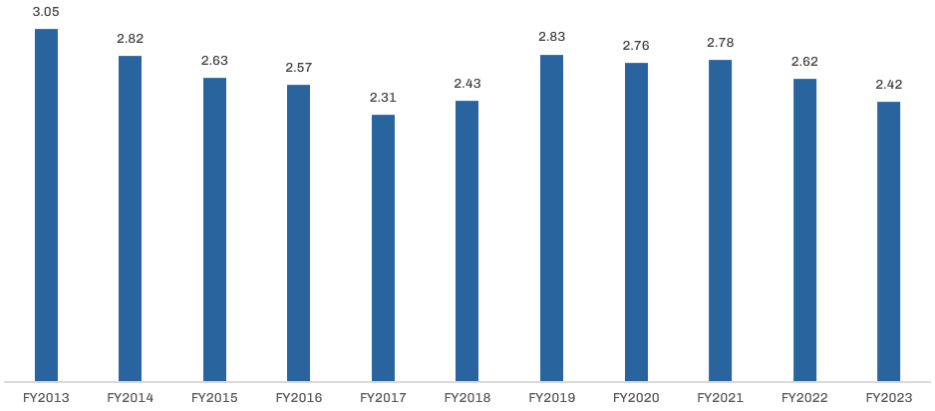
Table 2: Net Project Missed Volume (NPMV) (PKR Billion)

	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023
NPMV	1.945	1.41	11.17	3.94	1.18	10.52

Source: NEPRA State of Industry Reports (Various Years)

Transmission losses during transmission and during transformation have remained above 2% in Pakistan. The corresponding financial impact of these losses in FY2023 was PKR 30.8 billion. Reducing transmission and transformation losses should be a priority in the electric power sector, as it enhances the overall efficiency and sustainability of the grid.

Figure 7: Transmission and Transformation Losses (%)



Source: NEPRA State of Industry Report (Various Years)

3.1.3. System Reliability

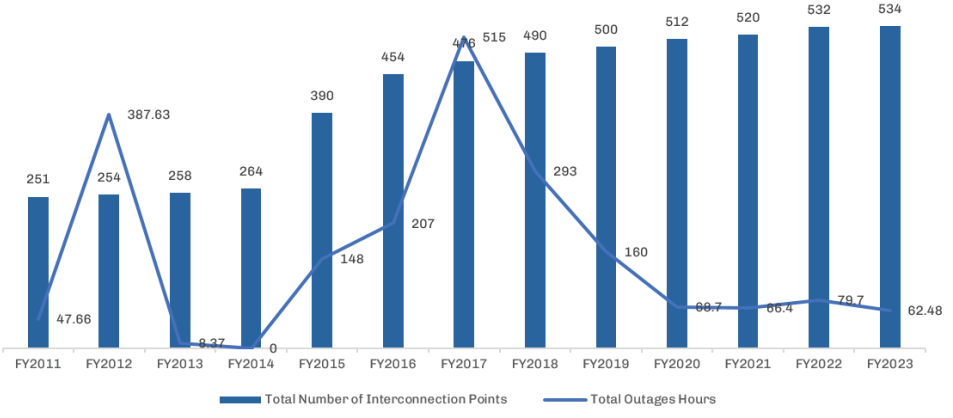
There are two main indicators to assess the reliability of a system, namely, system duration of interruption and system frequency of interruption. The system duration of interruption measures the average outage duration experienced by an interconnection point in a year. On the other hand, system frequency of interruption is a parameter that measures the average number of outages per circuit in a year.

As illustrated in Figure 8, since FY2011, the total number of outage hours shows a disoriented picture till the midway point, with spikes in FY2012 and FY2017 and hitting zero in FY2014. However, there has been a gradual decrease after FY2017. A slight rise in FY2022 could be due to the economic crunch and resultant capacity issues. On the other hand, the number of interconnection points has shown a steady yet positive trend over time. More interconnection points in a network generally means network expansion: more locations where different parts of the network can connect or interact. More interconnection points allow for redundancy in the network. If one connection point fails or experiences issues, electricity can still flow through

alternative paths, reducing the risk of widespread outages and enhancing the overall reliability of the grid. Also, increased interconnection points provide more flexibility in managing the flow of electricity. Grid operators can reroute power more efficiently in response to changes in demand, generation, or unforeseen events, thereby helping to maintain grid stability.

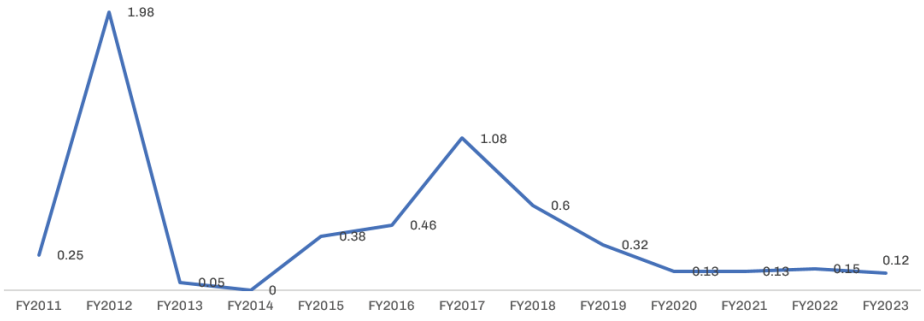
The duration of interruptions in the power system from FY2011 to FY2023 has exhibited fluctuations (Figure 8), with noticeable peaks and troughs over the years. Specifically, two significant spikes were observed in FY2012 and FY2017, during which the maximum interruption duration reached 1.98. However, after the peak in FY2017, there has been a gradual decline in interruption durations, indicating an overall trend towards improvement in system reliability. Notably, in FY2022, there was a slight uptick in interruption durations, albeit minor, which suggests the need for continued vigilance and proactive measures to sustain the downward trajectory observed in recent years. If we compare the system duration of interruption between 2010-11 and 2021-22, the percentage change indicates a 50% reduction overall.

Figure 8. Outage hours and interconnection Points



Source: NEPRA Performance Evaluation of Transmission Companies (Various Years)

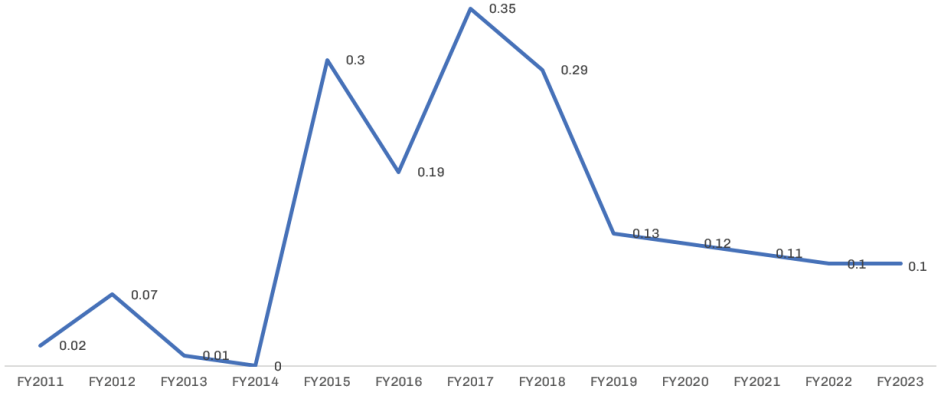
Figure 9: System Duration of Interruption (Hours/Point)



Source: NEPRA Performance Evaluation of Transmission Companies (Various Years)

Figure 10 shows that the frequency of interruptions per circuit in the system is not constant and varies over time. In FY2014, it went down to zero [2] but peaked again in FY2015 and FY2017. However, after FY2017, the frequency dropped significantly, reaching 0.1 in FY2023. According to the reported data, the percentage change in the system's interruption frequency has increased by 400% (from FY2011 to FY2023). This indicates that the duration of interruptions has been addressed to some extent, but the problem of a higher frequency of interruptions persists.

Figure 10: System Frequency of Interruption (Number/Circuit)



Source: NEPRA Performance Evaluation of Transmission Companies (Various Years)

3.1.4. System Security

The significant fluctuations in Energy Not Served (ENS), representing the unfulfilled energy demand measured in MWh within a particular zone and time frame due to insufficient resources, over the past few years, suggest that apart from extreme weather events, the infrastructure is aging, and maintenance practices may be lacking (Table 3). The number of incidents related to loss of supply has decreased since it peaked in FY2017, with a total of 165 incidents. It has declined steadily and reached a low point in 2021-22 with only 51 reported cases. However, there was a slight increase again in FY2023. The average duration per incident seems to follow a pattern of increase and decrease, but it notably increased in FY2023. The average ENS per incident also shows a similar trend. Over the past nine years, the total financial impact caused by supply loss incidents has amounted to approximately PKR 11.9 billion.

Table 3: Supply Incident Losses and its Financial Impact

	ENS (GWh)	Loss of Supply Incidents (No) A	Average Duration per Incident (Hrs: Min)	Average ENS per Incident (GWh)	Financial Impact per Incident (PKR Million) B	Total Financial Impact per Year (A*B) (PKR Million)
FY2015	533	125	1.12	4.264	42.6	5325
FY2016	143	87	2.24	1.644	8.322	724.014
FY2017	75	165	3.07	0.454	2.5	412.5
FY2018	469	142	2.06	3.3	17.5	2,485
FY2019	114	66	2.24	1.7	9.7	640.2
FY2020	17.3	62	1.06	0.3	1.4	86.8
FY2021	130.2	57	1.12	2.3	15.6	889.2
FY2022	9.4	51	1.36	0.2	1.8	91.8
FY2023	137.7	55	2.50	1.136	22.69	1,247.95
Cumulated Financial Impact due to Loss of Supply Incidents since FY2015						**11,902.46**

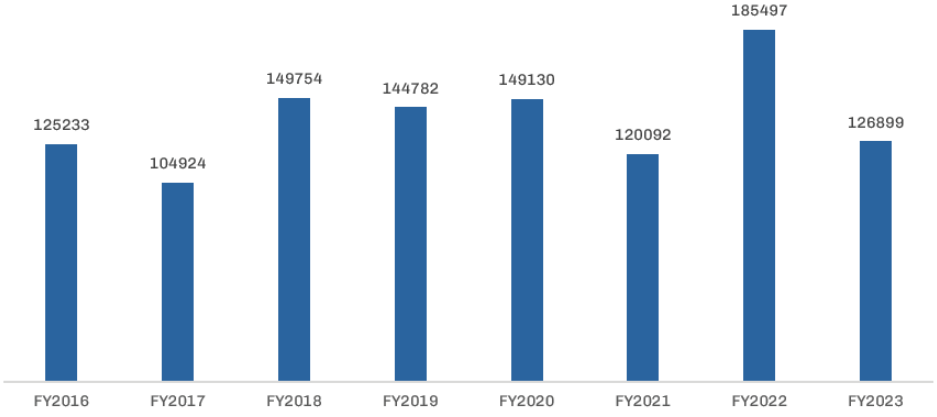
Source: NEPRA Performance Evaluation of Transmission Companies (Various Years) and Authors' estimates.

3.1.5. System Voltage and Violations

Per rule 7 of PSTR-2005,[3] voltage fluctuations of up to ±5% are permissible under normal circumstances, but in the event of (N-1) contingency, the range increases to ±10%. The criteria for reporting voltage fluctuations is applicable only when the duration of variation exceeds a continuous period of thirty minutes, as specified in Sub-Rules (2) and (3) of PSTR-2005. Unfortunately,

there has been no significant improvement in recent years, as indicated by Figure 11, which paints a passive picture of the situation.

Figure 11: Voltage Violations



Source: NEPRA Performance Evaluation of Transmission Companies (Various Years)

Rule 08 of the Performance Standards of Transmission (Rules 2005) sets limits for frequency. According to the frequency data reported by NTDC, there were variations in the frequency limits that went beyond the upper permissible limit of 50.5 Hz, with the highest frequency recorded being 50.66 Hz. Over time, frequency violations have decreased, suggesting improved NTDC functionality. Yet, in FY2023, the performance reversed, and there has been an increase in the frequency of violations.

Table 4: Frequency Violations in NTDC

	The number of times Frequency remained outside the Limits			Time duration the Frequency remained outside the Limits (In a year)		
	In a year	**Average/month**	**Average per day**	**Hours**	**Min**	**% of year**
FY2015	1264	105	3.5	250.33	15019.9	2.86
FY2016	248	21	0.7	37.9	2274	0.43
FY2017	35	2.9	0.095	4.2	252	0.048
FY2018	25	2.1	0.07	4.1	246	0.047
FY2019	25	2.1	0.07	2.98	179	0.34
FY2020	9	0.8	0.02	0.8	48	0.009
FY2021	4	0.3	0.01	0.6	36	0.007
FY2022	4	0.3	0.01	0.44	26	0.005
FY2023	15	1.25	0.04	1.7	--	0.02

Source: NEPRA Performance Evaluation of Transmission Companies (Various Years)

3.1.6. System Blackouts

In recent years, Pakistan has experienced several significant blackouts (Table 5). The most recent one was on January 23, 2023, causing widespread disruption and economic losses. Recent power outages have exposed significant flaws in the system. Typically, a blackout originates from a system malfunction that can trigger a chain of failures. Inadequate generation capacity, lack of spinning reserves, and transmission constraints are the primary causes of power outages. According to the NEPRA inquiry on January 23, 2023, blackout, the primary cause of the problem was NTDC/NPCC, apart from various power plants.

Table 5: Major Power Breakdowns in FY 2018 to FY 2023

Date	Details
August 01, 2018	Lahore_ tripping of 220 kV Bund Road Grid Station
August 12, 2018	Tripping of NTDC's 500 kV and 220 kV transmission lines in the South: High humidity & pollution affected power supply (PS) to KE from national grid (NG) & generation from 1320 MW Port Qasim Power Plant and WPP in Jhimpir & Gharo.
September 24, 2018	Same as above
October 02, 2018	Tripping of NTDC's 500 kV and 220 kV transmission lines in the South: High humidity & pollution affected PS to KE from NG & generation from 1320 MW Port Qasim Power Plant.
October 04, 2018	Same as above
October 25, 2018	Tripping of NTDC's 500 kV and 220 kV transmission lines in the South: High humidity, pollution & smog affected PS KE from NG & generation from 1320 MW Port Qasim Power Plant.
November 12, 2018	Same as above
January 25, 2019	The tripping of 500/220 kV transmission lines in Guddu, Shikarpur, and Multan regions due to extreme weather caused by dense fog/smog and pollution/contaminated layers on insulators caused by a variety of sources, i.e., sea, salt, and industries. It also caused the tripping of HUBCO, Port Qasim, and Guddu Power Plants, resulting in a power failure to parts of Sindh (NTDC & KE networks) & Baluchistan.
January 09, 2021	Tripping of 500 kV and 220 kV transmission lines due to faulty breaker at Guddu; isolation of system in North and South regions_ complete system collapsed (country plunged into darkness) because of cascaded tripping.
March 03, 2021	500 kV Jamshoro grid station, K2, KE split from NTDC network Circuits affecting 500 kV Jamshoro – Matiari Circuit 1 & 2, 500 kV Jamshoro – Dadu Circuit, 500 kV Jamshoro – China Hub Circuit, 500 kV Jamshoro – K2 Circuit and 220 kV Jamshoro – T. M. Khan Circuit 1 & 2
April 04, 2022	3701 MW load was interrupted due to tripping in various circuits
March 23, 2022	Tripping of 500 kV Jamshoro grid station, K2, KE isolated from NTDC network affecting: 500 kV Jamshoro - Matiari Circuit 1 & 2, 500 kV Jamshoro - Dadu Circuit, 500 kV Jamshoro - China Hub Circuit, 500 kV Jamshoro - K2 Circuit and 220 kV Jamshoro - T.M. Khan Circuit 1 & 2

October 13, 2022	**Partial System Blackout: 500 NKI-K2/K3 and 500 kV K2/K3 - Jamshoro T/L tripped due to conductor break down on red phase**
January 23, 2023	Full System Blackout: All systems from Sheikh Muhammadi to KE went under dark from 07:34:15 hrs, System frequency went up to 50.75 Hz and severe hunting was observed on 500 kV transmission lines. As a result, the following 500 kV Transmission lines tripped which resulted in isolation of North and South system followed by blocking of HVDC system. (i) 500 kV Muzaffargarh - DG Khan Circuit (ii) 500 kV Guddu - Muzaffargarh Circuit (iii) 500 kV Guddu - DG Khan Circuit (iv) 500 kV Rahim Yar Khan - Guddu 747 Circuit (v) 500 kV Guddu Old - Guddu 747 Circuit

Source: NEPRA State of Industry Reports (Various Years)

Power systems are intricate and operate near the boundary of steady-state stability. Various control and protection techniques are necessary to ensure these systems operate stably. Over time, countries worldwide have learned from experiences and improved their ability to withstand power outages. They have developed power systems incorporating various protection schemes to prevent unpredictable events and power failures (Malik, 2023).

Power outages, or blackouts, raise concerns about the effectiveness of protection methods in preventing such incidents. Unfortunately, blackouts happen frequently in Pakistan, where the power system still needs to be updated. Undoubtedly, due to the large geographical area the power system covers, there is a higher likelihood of faults or power disruptions. Yet, new algorithms have been developed globally to prevent power outages caused by malfunctions during significant disturbances. These countries' power systems still face malfunctions but have reduced incidents through improved maintenance and protective techniques.

In Pakistan, the most common reasons for these blackouts cited are transmission line overload, voltage collapse, equipment failure, poor maintenance, human faults, and mal-operating control systems (Cheema et al. (2022).

The transmission network is critical in delivering electricity over long distances to load centers. Tower collapses have become frequent in recent years, disrupting the power supply, posing safety hazards, and jeopardizing the integrity of the entire network. In 2022-23, there were 38 such incidents in 500 kV and 220 kV transmission networks, with 25 in the South, nine in the North, and four in the KE area (NEPRA, 2023).

NTDC struggles to upgrade its transmission system and adopt new technologies like ultra-high voltage transmission lines, static var compensators, and storage batteries. In areas with fog, replacing all disc insulators with polymer types or applying RTV coatings to reduce the tripping of main lines during the winter season has been delayed. The control system

is not good enough to track real-time disturbances or respond automatically to isolate problems before they snowball - no system redesigning for installing shunt reactors to energize during the low load period. NTDC does not comply with industry standards and uniform codes of conduct on the electric power system's safety, reliability, stability, integrated operability, and efficiency.

Due to outdated mechanisms and procedures, major blackouts and prolonged restoration periods are a significant concern in Pakistan. In addition to the absence of a black start facility in power plants to restart parts of the power system and recover from a blackout, grid stations and power stations are not equipped with synchronization devices. The SCADA system is only available on primary power systems, not secondary ones. Many power plants and grid stations are disconnected from system operator control rooms. Outdated communication modes and the lack of trained staff are also responsible for the delay in restoration.

In summary, NTDC faces efficiency challenges, which significantly affect the system's reliability and pose a risk to voltage stability, thereby leading to violations. The persistent issues in the transmission system reflect a lack of integrated planning and seriousness in strengthening and expanding the transmission network to optimize the utilization of available generation capacity. Transmission constraints such as over-loaded transmission lines, inadequate transformation capacity of power transformers, and transmission line outages are a few reasons behind the under-utilization of efficient power plants. It is crucial to make urgent improvements to address these issues. Electricity supply is crucial for economic activities. Extended power failures can disrupt most services and activities. Proper operational management and contingency planning are critical.

3.2. NTDC as a System Operator

The National Power Control Center (NPCC) operates within NTDC as a System Operator. It is responsible for short-term operational planning (one year ahead of real-time maintenance schedule); coordination (generation & transmission); real-time operation & control; generation scheduling; and ancillary services schedule. It ensures the system's integrity, security, quality of supply, compliance with emission requirements, and sufficient generation capacity to meet the system's demand. It evacuates power from generation plants to the distribution companies through NTDC's EHV network. It dispatches load on economic dispatch criteria - Economic Merit Order (EMO).

As a SO, NPCC is undergoing upgrades to improve its Load Dispatch System (LDS). In 2014, the LDS Phase-II was implemented, which involved replacing the SCADA system in NPCC, upgrading the telecommunication network, installing Optical Ground Wire (OPGW) on transmission lines, and installing new digital Remote Terminal Units (RTUs) at 500 kV and 220 kV grid stations and power plants. It also included software facilities such as an operating system, software maintenance tools, and database management.

In 2021, LDS Phase-III was executed to facilitate the transition from a single-buyer regime to a CTBCM. This phase is expected to accommodate various new projects related to renewable energy, such as RLNG, coal, solar, wind, and small hydro. The LDS system is designed to improve grid visibility and automation and enable seamless integration of renewables, thereby resolving some of the transmission constraints. The project is scheduled to be implemented by FY2025, and its timely completion is crucial for the smooth functioning of the system.

As per the Economic Merit Order (EMO), operating the available power plants is critical to avoid high electricity costs. Despite upgrades in the load dispatch system, in various instances, the operation of power plants violates EMO. Technical constraints hinder the System Operator's ability to evacuate electricity from efficient power plants. During FY2023, system constraints and under-utilization of efficient plants resulted in a financial loss of PKR 20.26 billion. NEPRA, in its State of Industry Report for FY2023, charged that despite the substantial investment allocated to NTDC, the System Operator and NTDC could not justify these technical constraints.

It means that NTDC still requires time to fix the existing constraints that are causing the operation of power plants in violation of EMO. Due to an inadequate transmission system, NEPRA extended the term of the generation

license of some power plants in 2021 despite the availability of unutilized take-or-pay power generation capacity in the CPPA(G) System - a burden on compliant consumers.

Likewise, when power plants are not used to their full capacity, generation companies are paid Part Load Adjustment Charges (PLAC) under their Power Purchase Agreements, increasing the per-unit electricity cost. In FY2023, PKR 46.6 billion was paid to power plants for PLAC, which could have been avoided through better load management planning and a Time of Use (TOU) tariff.[4] Operating baseload power plants at part load results in lower efficiency and higher generation costs, adding to the monthly fuel price adjustments.

NEPRA's 2021 report states that EMO is prepared solely based on fuel cost and variable O&M without considering other cost factors like PLAC, degradation factor, start-up charges, plant efficiency,[5] and plant location relative to load centers. EMO has yet to establish specific criteria for separately ranking take-and-pay and take-or-pay power plants.

A rigorous accountability system is crucial in effectively managing and rectifying technical challenges in economic dispatch, which is currently missing in Pakistan's power sector set-up.

In summary, NTDC efficiency challenges also significantly affect its ability to comply with merit order requirements, which is crucial to optimally utilize the available generation capacity.

3.2.1. NPCC as a Separate Licensee

The NPCC has demonstrated its operational independence through its System Operator (SO) functionality. As a separate licensee, it has shown capabilities in certain functional domains, indicating readiness for an expanded role under the Competitive Trading Bilateral Contract Market (CTBCM). NPCC's specialized departments, like Research and Development (R&D) and Regulatory Compliance, suggest that it has the potential to manage its operations effectively in the future and handle the complexities of an independent system operator role. However, the question remains whether NPCC can turn this potential into reality.

It was reported that a dedicated R&D department conducts regular operational studies to enhance the system. Besides, it recently hired consultants to support its R&D efforts. NTDC conducts comprehensive grid studies for new transmission lines, which include load flow, short circuit, and stability assessments. Independent Power Producers (IPPs) are mandated to conduct feasibility studies for proposed plants and grids; NTDC often oversees

these studies to ensure IPPs have the necessary support.

Despite the efforts, there has yet to be any significant improvement in its overall performance. As mentioned earlier, the impact and significance of location in the EMO order often go disregarded, potentially undermining the effectiveness of decision-making processes. NTDC tends to undertake studies reactively, primarily triggered by issues as they arise, rather than proactively implementing preemptive measures to prevent potential problems. This reactive approach might limit their capacity for anticipatory and preventive strategies. In short, NTDC functions primarily on a day-to-day basis without a defined long-term goalpost or regular strategic planning, which hinders its forward-looking capabilities.

Besides, separating NPCC could result in higher operational costs and redundant services already managed by NTDC. Establishing an independent entity demands extra resources and infrastructure, potentially raising overhead expenses, leading to a rise in per unit cost for consumers. Moreover, certain NTDC functions might need replication within NPCC as well.

In addition, inadequate human resource training and development pose significant barriers to preparing the workforce for their expanded roles. The shift of employees, especially those in Technical and Network Operation (TNO) roles, to NPCC's SO role and the added responsibility of load forecasting brings organizational complexities. Furthermore, financial constraints hinder NPCC's readiness for autonomy, requiring an estimated investment of $2-3 billion.

Likewise, high employee turnover, driven by appealing opportunities abroad, compromises the organization's continuity of expertise. NPCC also struggles with a bureaucratic work atmosphere and limited adherence to international human resource practices, hindering effective human resource management. Operational challenges, including a lack of real-time network clarity, pose significant hurdles, potentially leading to operational disruptions.

In parallel, within the power sector, opinions diverge on the separation of SO from NTDC, with concerns raised about potential crises in management and investment arising from such a division.

Additionally, NTDC faces several other hurdles when conducting grid studies for future energy transitions. One such challenge lies in keeping pace with the rapid technological evolution within renewable energy. Continuous adaptation to new technologies demands regular infrastructure upgrades and ongoing skill development within the organization.

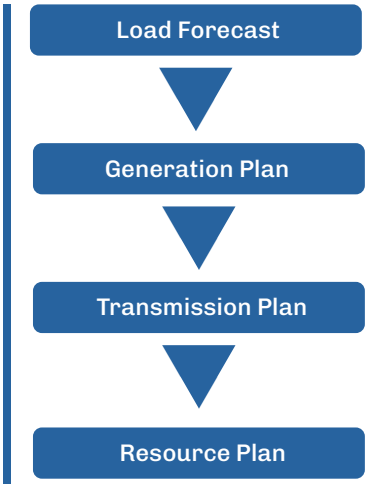
3.3. System Planning

NTDC is responsible for ensuring efficient and reliable electricity transmission across the country. At the heart of this lies a planning process. This guides the national grid infrastructure's expansion, maintenance, and optimization. The planning process at NTDC encompasses four core domains, as shown in Figure 12.

NTDC claims to have a robust planning process that involves rigorous analysis and forecasting to predict future electricity demand. This helps them to identify the transmission network requirements and allocate resources strategically to meet evolving energy needs.

On the contrary, several generation expansion plans have been framed in the past, with input and assistance from foreign and local consultants. In most of these plans and load demand forecasting studies by NTDC, the methodology had not evolved to cater to the power sector dynamics.

Figure 12: NTDC Core Domains



That is why investments to increase generation capacity remained separate from equivalent investments in downstream transmission & distribution infrastructure. Demand was inaccurately forecasted, resulting in excess system capacity and higher capacity payments.

As per Cheema et al. (2022), Pakistan's power sector has faced many issues due to the lack of research-based planning input for policymaking. This has led to an unsustainable and tumultuous journey since the early 1990s. Although the Grid Code 2005 provided guidelines for Pakistan's power sector, the Planning Code was not effectively implemented. The Planning Code outlines the planning process for the power system but was only recognized after 14 years in 2019 through the IGCEP 2040.

Box 2: Grid Code 2005 on Planning

According to the Grid Code 2005, the National Transmission and Dispatch Company (NTDC) is responsible for preparing and presenting a Ten-Year Indicative Generation Capacity Expansion Plan (IGCEP) or NTDC Plan to the National Electric Power Regulatory Authority (NEPRA) every year. This plan will cover a 0-to-10-year period based on a twenty-year forecast of the expected load demand and energy. The NTDC Plan will be developed using a Loss of Load probability (LOLP) methodology established under the Grid Code and NEPRA Transmission Performance Standards rules.

The NTDC Plan will serve as an input to create NTDC's Transmission Expansion Plan (TSEP). A comprehensive Transmission Investment Plan will be formulated, which will be based on the NTDC Twenty-Year Load Forecast and Indicative Generation Capacity Expansion Plan (IGCEP or NTDC Plan).

According to the Planning Code of the Grid Code, the System Operator must submit the Integrated Generation Capacity Expansion Plan (IGCEP) and Transmission System Expansion Plan (TSEP) to NEPRA for approval every April. In 2021, NTDC submitted the IGCEP for the year, but unfortunately, they didn't submit the TSEP. Despite this, NEPRA approved the IGCEP, marking the first-ever approved generation plan. However, NEPRA directed NTDC to submit the TSEP alongside the next iteration of the IGCEP for approval. Even after the approval of the next IGCEP in 2022, work on the TSEP was still ongoing, reflecting the limited working capacity of NTDC.

NTDC submitted Phase-I of the TSEP in FY2023. The plan covers four years until FY 2025-26. It caters to the generation projects of IGCEP 2022-31. However, as per NEPRA's State of Industry Report (2023), the submitted TSEP lacks evacuation plans and transmission cost details for candidate projects in IGCEP 2022-31, revealing incomplete cost estimates and alignment issues with existing frameworks. NEPRA directed NTDC to revise the TSEP so that it is in complete alignment with the IGCEP 2023-32 and includes all parameters. Finally, the revised TSEP along with IGCEP 2023-32 has been submitted to NEPRA in May 2024 for approval.

TSEP is an important document that plays a crucial role in the systematic growth of the power sector. It outlines the necessary improvements and expansions required to strengthen the transmission network, ensuring network efficiency, reliability, and capacity to meet the increasing energy demands. Failure to formulate these plans timely can disrupt the entire power sector supply, leading to significant financial costs and placing an extra burden on consumers. Furthermore, developing the Integrated Generation and Capacity Expansion Plans (IGCEP) for 2021 and 2022 could have been more efficient. Only following a planning tool (PLEXOS) without careful consideration does not make sense.

It is the lack of planning that an HVDC transmission line was built by Pak-Matiari Lahore Transmission Company Limited (PMLTC) to transport electric power from the southern region to the central and northern load centers spanning 886 km with a capacity to transmit 4000MW. The project achieved COD on September 01, 2021. However, the transmission line still needs to be fully utilized. In FY2023, the average utilization of this crucial infrastructure remained at 39.6% (1,584 MW) of its designed capacity. Due to the take-or-pay contract, the company is entitled to receive payment for the total capacity, even though it is not fully utilized, placing an additional burden on electricity consumers. The projects' cost structure and operational efficiency should have been evaluated in advance.

Furthermore, NEPRA reports highlight that NTDC, in most cases, has been unable to meet the timeline as stated in the approved Project Concept Papers (PC-I). The interconnection timelines are revised repeatedly, resulting in cost overruns - delay in interconnection as per design delays evacuation of power from cheaper sources in a reliable manner.

Some of the factors that have affected power system planning in the past include lack of processes, brain drain, insufficient institutional and human capacity, lack of formal capacity-building opportunities specifically for planning purposes, posting of professionals in the planning department as transit lounge, obsolete software, delayed digitalization, limited R & D activities, and limited regulatory compliance.

On the other hand, there are exceptions as well. Despite NTDC's crucial planning role, procuring extra generations without NTDC's involvement has also been a recurring issue. Instances such as the Karimo power plant underscore this trend. Some experts within the power sector have emphasized that NTDC bears the exclusive responsibility for planning and that the government's involvement should be minimized. Concerns have also been raised about the need for more NTDC Board independence. A noted expert has expressed concern that Pakistan may remain stuck in a capacity trap dilemma in the future due to these interferences and inefficiencies in planning processes.

Previously, the Transmission and Load Forecast Planning Department submitted IGCEP (Indicative Generation Capacity Expansion Plan) primarily for the generation cost. However, with the introduction of Grid Code 2023, there's a directive to integrate the transmission cost into each power plan, optimizing considerations for distance-related issues. That's why Phase I of TSEP 2023 was not accepted by NEPRA. NTDC recently launched a project titled 'Power Sector Improvement Activity' to facilitate compliance with grid code standards. As informed, NTDC is working on improving its planning framework by integrating transmission costs into power plans to optimize distance-related challenges and ensure cost-effective grid expansion.

3.4. Procurement Imbroglio

NTDC asserts that it follows a robust procurement process to guarantee the acquisition of assets in line with industry standards and operational requirements. The method includes procuring crucial software such as planning and system protection tools, which are essential to meet system needs and comply with industry benchmarks.

However, hardware procurement faces several hurdles due to outdated PPRA rules restricting acquiring essential equipment such as 11KVA filters, transformers, wires, and related assets based solely on the least-cost criterion. The lack of flexibility in these rules hinders the acquisition of equipment aligned with the latest industry standards. NTDC is of the view that the lack of power sector experts within PPRA exacerbates the issue, impeding the understanding of the significance of acquiring state-of-the-art equipment. But the fact of the matter is, it is the job of NTDC to present the best possible technical options for PPRA review.

Experts and published reports[6] have established significant procurement process challenges at NTDC. As per the evidence, functional offices often work in isolation and lack knowledge of factors like Public Sector Development Programs, multilateral donor agencies roles, SDG goals, etc. Project concept papers (PC-1s) are often unrealistic and fail to consider ground realities, such as financing arrangements, land acquisition, etc.

There are delays in project execution even after the approval of the PC-1. This is because some projects are approved without securing financing. No standard operating procedures (SOPs) are in place to determine the priority for procurement or projects. Urgent work is executed reactively rather than proactively, which leads to a fire-fighting approach rather than a well-planned project management process.

There are no SOPs to determine minimum inventories, inventory turnover, trigger points, lead times, etc.; operational requirements are rarely consolidated and translated into inventory and management plans. Often, there are disproportionate procurements of inventory, such as unnecessary build-up or a lack of critical stocks. Inventory disposal and the maintenance of existing stocks are chronic challenges.

According to a project procurement timeline, the preparation of PC-1 to the beginning of the project takes at least three times longer than the prescribed time. This delay is due to bureaucratic norms, procedures, and continuous external interference, which hamper the reform process. Over time, procurement processes have become increasingly bureaucratic, to the point where even the most qualified staff become unresponsive to minor deviations.

The procurement documents are inconsistent regarding document types, evaluation/qualification criteria, contract mode/type, etc., confusing market/industry participants and raising doubts about process transparency. Pre-market surveys are often not conducted.

Procurement plans/ documents are often hidden due to a lack of certainty about needed financial resources and dreary human behavior. Transparency is crucial for obtaining the best product and value for money. Lack of transparency discourages quality-oriented firms, leading to poor-quality work and increased costs. The lack of pre-qualification mechanisms and standard procurement documents makes the procurement process less competitive and complex.

Another challenge is the absence of standardized bidding documents that specify product specifications, designs, and load forecasting. Efforts have been made to create such documents, but no policy mandates regular updates to ensure relevance and compliance with evolving industry standards. Integrating these documents with tender or bidding processes

remains a pending issue.

There is a shortage of skilled professionals and experts in procurement and project management frameworks. The lack of incentives has resulted in a scarcity of necessary expertise, leading to superficial handling of planning, preparation, tendering, and contracting. Other departments involved in the procurement cycle also suffer from human resource shortages, leading to delays and complications.

Asset management improves the electricity grid's performance and quality through organized activities. It helps manage critical infrastructure cost effectively by optimally controlling assets over their life cycle. NTDC's Asset Management Department is inefficient and ineffective, not compliant with international standards (Box 3). There has been a significant loss of power transformers and related equipment in recent years.

Box 3: Asset Management at NTDC

- NTDC's technical services group has developed maintenance SOPs for electrical assets. These SOPs are not being followed, leading to asset failure and high costs for corrective measures.
- There is no appropriate database for managing assets.
- There is a shortage of trained and skilled workforce.
- There is a shortage of maintenance tools & plants and testing sets.
- Insufficient power shutdowns for maintenance.
- There is a lack of proper logistic support and an absence of a Geographic Information System (GIS).
- No expert intelligent systems, such as online Dissolved Gas Analysis (DGA) and online Partial Discharge, are implemented to prevent unforeseen events and overall system constraints that may cause blackouts.

Source: Cheema et al., 2022

3.5. Regulatory Compliance

NTDC reports that it maintains a robust regulatory framework to ensure transparency and stakeholder engagement in tariff determination. They calculate their revenue requirements in detail, which offers a comprehensive view of transmission tariff needs based on operational, financial, and income-related aspects, resulting in precise cost allocation. Moreover, NTDC is adaptable to market changes through its CTBCM-related reforms, which enhances competitiveness. Nevertheless, tariff fluctuations create financial uncertainty and operational inefficiencies, impacting stakeholders and consumers.

The company invests in infrastructure expansion and projects to ensure reliability, cater to the growing demand, and strengthen the transmission network. That's why NTDC has shown some progress in its commitment to compliance, following National Grid Code 5 and its sub-codes, including PC4 and PC5. The organization is now notifying NEPRA about the Indicative Generation Capacity Expansion Plan (IGCEP) and submitting it for regulatory review, which was not done in the early years.

Some critical factors determine the efficiency of NTDC and its compliance with Grid Code 5 and its sub-codes. These factors include compliance rate, regulatory reporting, and IGCEP integration. Based on the reports submitted to NEPRA, it is evident (Section 3.1) that NTDC is trying to follow the performance criteria set by the regulator.

It is important here to highlight that NTDC has evolved from managing three roles (CPPA, TNO, and SO) to becoming a National Grid Company after the separation of CPPA in 2007. The organization claims to have robust human resources, well-developed infrastructure, and substantial financial capabilities, providing a solid foundation for fulfilling its role as a national grid company. However, the assessment in previous sections does not fully support this claim.

NTDC's utilization of IGCEP to identify optimal power combinations with the aim of minimizing generation costs reflects the company's commitment to benefiting consumers by transferring cost reductions. However (as discussed earlier), the effectiveness of this strategy will be limited without a parallel Transmission System Expansion Planning (TSEP) and an accurate demand forecasting mechanism to prevent the growth of capacity payments.

NTDC reports certain challenges that are affecting its performance. For example, an international consultant hired to update Grid Code 2023 failed to deliver despite being paid. Disagreements with NEPRA regarding proposed changes complicated the process, leading to the formation of a committee comprising NTDC engineers. Delays in forming the mandated review panel following changes in the NEPRA Act 2018 have left identified gaps in existing grid codes and operational procedures unresolved. Additionally, NTDC's reactive approach to document preparation signals a lack of proactive initiative.[7] Due to internal inefficiencies, the organization struggles to meet Grid Code deadlines.

The electric power transmission system is crucial for transferring electricity from its generation sources to distribution networks. Its inefficiency or inadequacy severely compromises overall energy infrastructure, leading to power outages and economic losses. The NEPRA State of Industry Report 2023 revealed that fossil fuel power plants, despite being inefficient, are operating beyond their license lifespan. The reason being their location and transmission limitations, indicating medium to long-term planning failure at NTDC. Also, the failure to utilize existing capacity with take-or-pay contracts is increasing the capacity payment burden for consumers. The increase in capacity price in the last fiscal year was 36%, much higher than the decrease in energy price (10%) resulting from not using the existing capacity.

In this section, we have identified that the performance of NTDC has remained below average in most of its functions. In the next part, we will examine factors that could be hindering NTDC's effective performance or that are, in some way or another, responsible for internal inefficiencies.

4

Financial Security

4. NTDC'S Financial Security

NTDC is a profitable entity (Table 6). While its profits have fluctuated over the years, it remains one of the few state-owned energy companies with a positive net income. However, the net profit margin to sales ratio (Table 7a) has declined significantly over the last six years.

Table 6: NTDC Financials (PKR million)

Year	Use of System/ Wheeling Charges/Sales	Other Income	Operating Expenses	Finance Cost	Profit Before Tax	Profit after Tax for the Year
2014	19,836	935	12,340	1,363	7,068	**7,342**
2015	22,236	1,520	11,711	1,831	10,214	**10,409**
2016	27,546	1,282	13,755	1,498	13,574	**9,227**
2017	31,326	1,532	16,166	1259	15,432	**10,585**
2018	36,744	969	17,141	4575	15,997	**14,736**
2019	41,989	1,993	21,827	8,119	14,037	**11,236**
2020	43,445	4,216	27,460	10,327	9,874	**9,246**
2021	53,944	2,406	30,538	7,923	17,888	**12,740**
2022	76,326	4,133	33,855	10,137	36,314	**16,564**
2023	73,861	5216	41,459	16,046	19,091	**12,399**

Source: NTDC Annual Financial Statement 2021-22

The decreasing ratio of returns on assets indicates that the NTDC's efficiency in generating profits from its assets has decreased over the years. Similarly, the decreasing return on equity shows that NTDC is not effectively using its shareholders' equity (GOP-88% and employees-12%) to generate profits. These ratios undeniably demonstrate a downward trend in the Company's financial performance.[8]

Table 7a: Profitability Ratios (%)

	Operating Profits to Sales	EBIT to Sales	Operating Expenses to Sales %	Return on Equity (after tax)	Return on Capital	Return on Assets	Net Profit Margin (after tax) to Sales
FY2016	49	50	52	11	7	3	34
FY2017	53	56	47	12	7	3	40
FY2018	53	56	47	12	7	4	40
FY2019	48	53	52	7	6	3	27
FY2020	37	4	63	6	5	2	21
FY2021	43	48	57	7	6	3	24
FY2022	55	61	45	9	11	3	22
FY2023	41	48	59	6	7	2	17

Table 7b: Liquidity and Financing Ratios (%)

	Current Ratio	Acid Test	Debt/ Equity Ratio
FY2016	1.61	1.45	70
FY2017	1.64	1.34	73
FY2018	1.48	1.25	86
FY2019	2.35	1.83	76
FY2020	2.10	1.71	87
FY2021	1.72	1.36	95
FY2022	1.33	1.11	106
FY2023	1.14	0.95	142

Source: NTDC Annual Financial Report 2022-23

4.1. Finance Cost

Nonetheless, all the financial metrics demonstrate increasing reliance on loans (Table 7b). Likewise, NTDC's ability to pay off its current liabilities has decreased since FY2019. The current ratio (working capital ratio) measures how well a company can meet its short-term obligations, such as fixed operational costs and short-term debt. It also shows a downward trend.

NTDC, despite being one of the few state-owned companies that generate profit, its performance is not up to the mark. NTDC relies on donor funds to enhance its operational capabilities. This is why finance costs play a significant role in its expenses. Over the last few years, the significant increase in finance costs suggests more reliance on loans to fund capital projects, leading to financial pressure from rising interest rates.[9]

Finance costs primarily include interest expenses on borrowings, such as loans and bonds, and other costs associated with raising and managing funds. NTDC's long-term liabilities consist of more than 63% of its long-term financing share, which includes secured financing from banking companies and foreign loans, such as those from ADB, World Bank, JICA, etc., that are re-lent by the GOP to NTDC.[10]

The data also provides insights into NTDC's debt management practices and capital structure. More growth in finance costs (28%) relative to revenue or operating income (14%) may indicate an increasing reliance on debt financing. In other words, increasing NTDC's financial risk could impact its future profitability.

NTDC's debt-to-equity ratio[11] has increased steadily from 70% in 2016 to 142% in FY2023 (Table 7b). This trend indicates that a higher proportion of NTDC's financing has come from debt than equity. Equity refers to the financing provided by the company's shareholders. However, in the case of NTDC, it is a non-listed company with the government as the majority shareholder, and its paid-up/share capital stands at PKR 52.7 billion, comprising PKR 5.27 billion ordinary shares with a nominal value of PKR 10 each.

The company is not trying to attract capital investments through listing on the stock exchange. Despite being an independent corporate company by law, efforts towards commercializing its operation have yet to be made, as is happening across many countries globally.

Although debt can provide access to funds and growth opportunities, it also increases financial leverage and risk. This is particularly true if NTDC encounters difficulties in servicing its debt obligations (finance costs) due to delays in tariff determinations.[12] In recent years, NTDC's high debt-to-equity ratio has raised concerns about its financial stability and vulnerability to economic conditions or interest rate changes.

4.2. Use of System/Wheeling Charges/Sales

The Use of System (UOS) charges are the fees imposed for transmitting electricity through the grid infrastructure. As NTDC acts as the backbone of the country's power transmission network, enabling the movement of electricity from generators to consumers across regions, UOS represents the payment by consumers for using its transmission lines and facilities. There is about 14% growth in UOS charges earned by NTDC from FY2014 to FY2023 (Table 6).[13]

An increase in wheeling charges for the transmission company indicates a thriving electricity market with heightened activity driven by economic growth, industrial expansion, and infrastructural development. However, Pakistan's electricity market is not fully functional, and the economy (including industry) is struggling for many reasons, including rising energy tariffs. In other words, the positive trend in UOS reflects expanded transmission capacity and enhanced NTDC's infrastructure utilization, which burdens consumers if inefficient (as noticed in Section 3).

The UOS or Wheeling Charge contributes 3% per unit tariff. However, the overall inefficiency in the transmission system increases energy and capacity costs; it adds to Transmission and Distribution (T&D) losses. As previously mentioned, the unavailability of transmission infrastructure is responsible for growing financial losses in the sector, which consumers bear through financial cost surcharge.

4.3. Other income

NTDC's other income has shown an upward trend, increasing from PKR 935 million in 2014 to PKR 5,216 million in 2023 (Table 6). This reflects NTDC's little efforts to explore and capitalize on supplementary income sources beyond its primary transmission activities. Diversifying its revenue sources has reduced NTDC's reliance on a single income stream, improved financial stability, and reinforced resilience against market volatility by merely 2% from FY2014 to FY2023.

4.4 Operating Expenses

NTDC's operating expenses include maintaining and operating its transmission infrastructure. From 2014 to 2023, the operational costs of NTDC have increased consistently, more than triple from PKR 12,340 million in 2014 to PKR 41,459 million in 2023 (Table 6). This increase is due to inflation, expansion of infrastructure, workforce growth, and rising maintenance costs. Interestingly, in FY2023, salaries, wages, and other benefits account for the highest share of operating expenses, about 51% of the total operating costs (Table 8).

During the interviews with various departments, it was mentioned that there is a growing emphasis on research and development (R&D) activities. However, there is no dedicated head for R&D activities. Likewise, there is no separate head for staff training or capacity building. Perhaps capacity building or training has been allocated under a different category. However, there is no explicit mention of it. It is worth noting that there has been a significant increase in professional charges from PKR 23.5 million in FY2021 to PKR 95.3 million in FY2022. However, dropped again to PKR 24.6 million in FY2023.

Table 8: NTDC Operating Expenses (PKR million)

	FY2021	FY2022	FY2023
Salaries, Wages & other Benefits	12,998.2	15,556	20,981.1
Repairs and Maintenance	592.7	599.7	808.02
Rent, Rates and Taxes	96.2	164.7	149
Utilities	95.1	182.7	182.7
Vehicle Running and Maintenance Expenses	293.1	418.1	741.9
Travelling and Conveyance	247.7	283.9	335.5
Office Supplies	19.2	22.3	38.1
Legal Expenses	15.7	11.8	16.2
Professional Charges	23.5	95.3	24.6
Auditor's Renumeration	2.5	3.2	3.6
Insurance	285.8	294.9	305.3
Advertisement	11.6	5.6	1.8
Subscription	0.9	1.1	17.1
Depreciation	14,128	14,468.3	15,252.7
Depreciation of right of use assets	52.4	53.6	56.1
Provision against CWIP	1,527.9	1,566.5	1,768.9
Provision for slow moving stock	---	---	115.5
Others	145.2	128	660.7

Source: NTDC Annual Financial Report 2021-22 and 2022-23

5

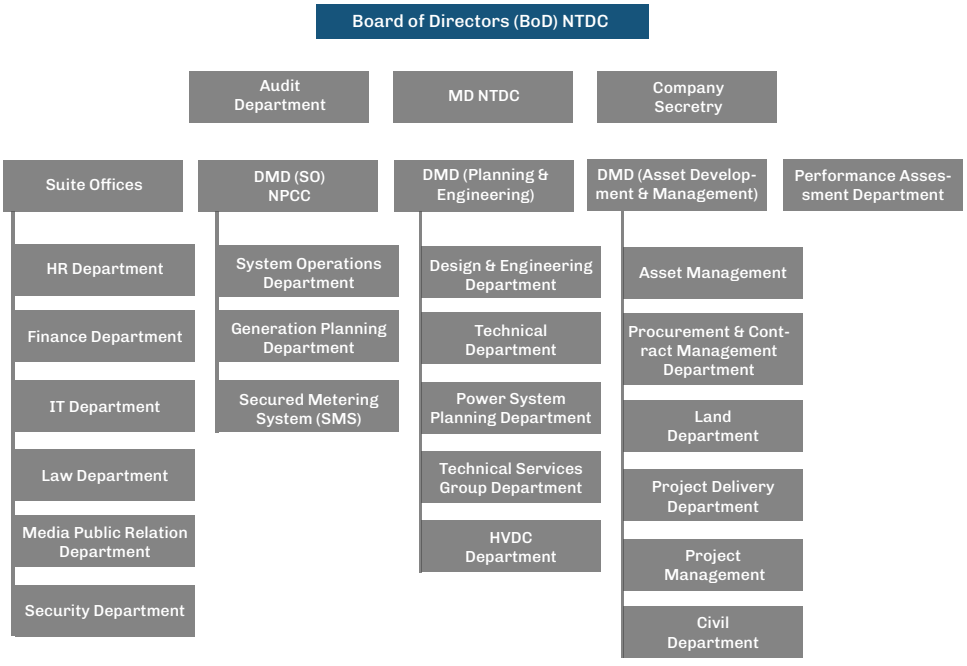
Governance at NTDC

5. Governance at NTDC

After reviewing NTDC's performance and financials in Part 4, it is evident that the issue is not the shortage of money but rather the effectiveness and quality of spending and resource management. The critical factor is the decision-making process regarding investments and expenditures.

NTDC has a well-structured governing body and a separate department for each specific function (Figure 13).

Figure 13: Board of Directors NTDC



Source: NTDC Annual Report 2022

5.1. Board and Senior Management

The audit report for FY2023 states that the board's composition complies with the Public Sector Companies (Corporate Governance) Rules, 2013. The report states that the board members are professionals with extensive technical experience in various fields. Table 9 reports the number of independent directors and board meetings annually.

Table 9: NTDC Board composition

Date	Independent Directors	Non-executive Directors	Board Meetings
June 2023	7	5	22
June 2022	4	5	27
June 2021	5	5	33
June 2020	5	5	12
June 2019	4	3	10

Source: NTDC Annual Financial Reports (various years)

An investigation into the NTDC board members appointed in FY2023 uncovered that many were appointed without proper consideration for avoiding conflicts of interest or implementing a sufficient cooling-off period, such as six months. The significant meeting fee seems to be a compelling factor for serving on the NTDC board. On average, each meeting in FY2023 costs PKR 58.27 million (Table 10).[14]

According to NTDC officials, NTDC is competent, well-trained, and experienced in carrying out its duties. However, the lack of established corporate rules and non-professional boards[15] and potential external interference in the board's independence create operational obstacles and hinder effective decision-making processes. The presence of non-expert members and excessive government representation compromises decision-making.

In the past decade, NTDC has faced several managerial challenges that have hindered its ability to supply adequate power to the distribution companies. These challenges include:

- A non-professional Board of Directors (BOD) and temporary Managing Directors (MD).

- Communication hurdles within the organization, limiting staff interactions with the board members and the MD. These restrictions hinder open communication channels, potentially affecting effective decision-making.

- Bureaucratic obstacles, such as limited accessibility for staff below BPS 20 to engage with the MD, further obstruct effective communication and collaboration.

MDs at NTDC usually serve for a limited period of up to six months, and most of the time, their appointments are politically motivated rather than based on their management skills. Frequently changing MDs creates challenges in achieving financial efficiency and increases incentives for corruption. Numerous experts in the power industry have verified this. Likewise, the company executive's charging of meeting fees in 2021 (Table 10) suggests the exploitation of unnecessary advantages. The CEO (MD) position is reportedly contractual, but allocating funds as retirement benefits does not seem reasonable (Table 10).

Table 10: Remuneration of Management, Board Directors, and Executives (Million PKR)

	Chief Executive Officer*			Directors			Executives		
	FY2023	FY2022	FY2021	FY2023	FY2022	FY2021	FY2023	FY2022	FY2021
Remuneration	8.225	9.85	3.216						
Meeting Fee	-	-	2.220	17.220	28.485	33.965	1281.88	381.09	334.04
Bonus	0.210	0.256	0.305	-	-	-	61.08	30.00	35.65
Utilities	0.222	0.072	0.222	-	-	-	66.63	20.08	23.18
Housing	0.709	0.721	0.492	-	-	-	170.70	32.70	52.60
Retirement Benefits	0.832	-	-	-	-	-	281.95	228.44	54.10
Total	10.198	10.898	6.455	17.220	28.485	33.965	1862.2	692.31	499.57
No. of Persons	1	1	1	19	18	11	492	111	117

Source: NTDC Annual Financial Report 2021-22 and 2020-23
*MD in NTDC; in addition, certain executives and company MD are provided with free use of Company's maintained cars and medical facilities.

The power to appoint MDs lies with the Power Division (PD) and the boards. However, since the PD often has a significant presence on the boards, their influence empowers the boards' decisions.

No significant change can be expected in NTDC affairs if it continues to be governed by bureaucracy. After the previous management retired, the PD made arbitrary temporary appointments to fill positions (Appendix A). Inexperienced MDs and board members often take a dominant approach to demonstrate their competence, which can harm the organization.

The government generally ignores input from industry professionals while favoring individuals with questionable qualifications as a solution. This same approach is used in selecting members of the BOD of government-owned entities like NTDC. The selection based on merit only lasted for a short period.

Drafting and approving job advertisements for senior positions in the NTDC (and any other state-owned energy companies) lacks a set format, resulting in discrepancies in the experience, education, and age criteria mentioned in the ads. This highlights the confusion prevailing in the sector.[16] If the professionals are not given the autonomy to manage the affairs of NTDC independently, the challenges and inefficiencies the organization faces will only persist and worsen.

5.2. Human Resources and Capacity Building

The total number of NTDC employees, as of June 2023, was 10,040, a significant increase over the years. In FY2014, the total NTDC employees were 8,262. In the top cadres (BPS 17-20), about 81% are engineers, and from (BPS 1-16) about 44% are engineers or technical staff. The substantial presence of support staff[17] at NTDC unequivocally demonstrates the level of political influence, a feature not evident in transmission companies in developed countries.

Employees at NTDC are required to undergo two training programs to facilitate career progression, administered by WAPDA Staff College in Faisalabad and WAPDA Engineering Academy in Islamabad. NTDC offers management-focused sessions in Islamabad and technical training in Faisalabad. In addition, they have partnered with LUMS to provide management training sessions under a formal MOU.

Moreover, NTDC provides training on equipment maintenance, grid management, and protection systems that cater to Pakistan's grid needs, with the help of dedicated training centers equipped with practical facilities. However, there are still some significant issues that need to be addressed:

- External influences, such as the Federal Secretary and political pressures, undermine HR decisions, impacting the effectiveness of HR policies and practices.
- There is a disconnect between financial stability and employee policies at NTDC. Despite having a stable financial structure, the high turnover rate signifies a lack of employee-friendly policies.
- Flawed human resource (HR) policies lead to skilled employees leaving for better salaries and benefits abroad — no performance based annual bonuses/ incentives. In some countries (such as the UAE), collaborative benefits like hotel discounts, transportation, and utilities are offered to create better work environments, which may reduce employee turnover.[18]
- Lastly and most significantly, the training curriculum is outdated and does not meet international standards. Instead, it's internally designed and delivered by the Technical Services Group, potentially lacking the global perspective or benchmarks found in international standards.

It has been claimed that NTDC is making progress by involving more professionals and focusing on research and development activities. However, their financial statements do not explicitly reflect any R&D work (as mentioned in Section 4).

Despite having enough capacity and human resources, persistent inefficiencies have resulted in citations from NEPRA regarding merit orders and voltage violations. The primary reason for not upgrading the transmission system is poor management of affairs, not the lack of funds. It was poor management that the country experienced a power outage for over twelve hours on January 23, 2023. Our assessment (documented in previous parts) identified a need for more departmental capacity building to align with international standards.

Any positive change in the sector depends on a change in its governance structure rather than power availability. Due to the lack of structural reforms, NTDC faces several challenges in enacting comprehensive changes. The hierarchical controls from Federal entities further impede operational efficiency and staff performance.

The focus of NTDC's operations is primarily on day-to-day activities instead of a cohesive long-term growth or improvement strategy. Additionally, the industry reporting framework is not aligned with international standards. It relies on past benchmarks, which hinders comprehensive evaluations essential for substantial operational enhancements.

6

Charting New Horizons

6. NTDC - Charting New Horizons

NTDC is integrating advanced technologies to enhance its operational efficiency. Notably, adopting High Voltage Direct Current (HVDC) technology for transmission lines exceeding 800 meters has significantly reduced transmission losses. NTDC's strategic initiative to implement double transmission lines from Mitiari to Lahore for N-1 contingency planning demonstrates its commitment to grid reliability.[19] The organization's adoption of advanced system protection software also reinforces its dedication to ensuring the safety and reliability of the grid infrastructure.

In recent years, the NTDC has realized the importance of planning and making decisions based on data-driven insights. Moreover, the company has recognized the significance of recommendations made by technical experts who rely on data and analytics. NTDC switched to PLEXOS from WASP for generation planning (IGCEP 2021 and 2022), which allows for optimized decisions. Yet, more needs to be done to digitize input data for better demand forecasting, generation optimization, and resource planning.

NTDC is taking steps towards transitioning to renewable energy sources. They have signed multiple purchase agreements with renewable energy producers, such as Hydro China Dawood Wind Power Plant (HCDWPP), with whom they signed a Power Purchase Agreement to purchase 50MW of wind energy for 20 years. While these agreements are a positive step towards integrating renewable energy into the national grid, NTDC needs to increase the scale of these agreements to boost renewable energy penetration significantly. Most significantly, NTDC needs to make a serious effort to ensure the successful evacuation of these renewable energy sources.

NTDC proposed amendments to the outdated Grid Code 2005 due to the emergence of wind and solar power in Pakistan's energy landscape. The Grid Code Review Panel, comprising industry experts and university professionals, was formed to strengthen grid code development. This diverse panel aims to improve renewable performance through quality studies, which currently do not exist.

The Planning Department's Technical Services Group (TSG) uses simulators for stability studies to stay ahead of potential issues. NTDC has taken a significant step forward by launching a comprehensive study every 15-20 years to identify the current problems and constraints.

However, NTDC, like any other organization, is not immune to challenges and shortcomings. One of its biggest challenges is to keep up with the evolving energy transition pathways and technological advancements. Integrating modern software and technology involves high costs. The bureaucratic inefficiencies often lead to delays, ultimately hampering the timely implementation of technical upgrades and further increasing costs.

Additionally, the organization lacks self-initiatives, particularly in essential research for integrating renewable energy sources. All the above initiatives are influenced by external funding agencies. This affects the strengthening of transmission networks necessary to allow power evacuation and maintain power quality.

A lack of clear vision from the board impedes efficiency, hindering NTDC's readiness for the shift towards renewable energy integration. As mentioned in the previous sub-section, communication issues within the organization affect timely decision-making and obstruct effective collaboration.

The Gwadar microgrid is an excellent example of the potential for off-grid electrification. However, for microgrids to make a substantial impact, they need to be smoothly integrated with the national grid. Overcoming technical challenges, including synchronizing frequency and voltage with the main grid, implementing safeguards against accidental power supply during outages, and maintaining consistent power quality, is essential to ensure seamless integration. Failure to address these challenges could result in equipment disruptions during integration.

7

Conclusion & Way Forward

7. Conclusion And Way Forward

The electric power transmission system is crucial for transferring electricity from its generation sources to distribution networks. NTDC has been expanding transmission lines and adding grid stations, improving the power transmission network's reliability and overall grid resilience. Yet, the transformation capacity (25950 MVA) is still insufficient against the installed capacity of 43,749 MW.

Immediate action is imperative to address transmission network inadequacies causing losses to the power sector and burdening consumers. The solution lies in a robust National Grid system, capable of efficiently transmitting power from any power plant to load centers nationwide. Addressing system constraints can ensure that the most efficient power plants can operate continuously at their maximum capacity.

Undoubtedly, NTDC is adopting some global best practices in its operations. However, a consistent and long-term approach is required.

Technology, Innovation, and Operational Efficiency

Smart Grid Technologies: NTDC is implementing smart grid solutions like automated meter reading, advanced distribution management systems, and data analytics to improve grid efficiency, reliability, and resilience.

High-Voltage Direct Current (HVDC) Transmission: Utilizing HVDC technology for long-distance power transmission projects, minimizing energy losses and increasing network capacity.

Condition-Based Maintenance: Employing advanced tools and sensors to monitor equipment health and predict potential failures, enabling preventive maintenance and reducing downtime.

International Standards and Certifications: By adhering to international standards like ISO 9001 for quality management and OHSAS 18001 for occupational health and safety, NTDC demonstrates commitment to best practices.

Renewable Energy Integration: In 2021, the third phase of the Load Dispatch System (LDS) was implemented to transition to a CTBCM, accommodating various new energy-related projects. The LDS system improves grid visibility

and automation, seamlessly integrating renewable energy sources. The timely project completion by FY2025 will resolve some of the transmission constraints.

Environmental Impact Assessments: Conducting thorough environmental impact assessments for new projects and implementing mitigation measures to minimize environmental damage.

Energy Efficiency Initiatives: Implementing energy efficiency initiatives within operations and promoting energy conservation among consumers.

Stability Studies: The Planning Department's Technical Services Group (TSG) uses simulators for stability studies to stay ahead of potential issues. NTDC has taken a significant step forward by launching a comprehensive study every 15-20 years to identify the current problems and constraints.

Despite implementing these measures, NTDC has encountered some challenges that require attention. These include :
Outdated Communication Methods — NTDC still relies on obsolete phone call methods in the System Operations (SO) department to shut down or turn on certain plants, hindering efficiency and effectiveness. This is also one of the reasons for delays in restoring the transmission system after blackouts.

Fault Isolation in Transmission Lines - failure to isolate the affected area can cause the fault to spread further. However,

- Implementing Supervisory Control and Data Acquisition (SCADA) software could assist in promptly isolating these issues and preventing widespread problems. NTDC should adopt SCADA technology specifically for renewables to enhance management and monitoring capabilities.

Ensuring operational reliability has become increasingly challenging as the country's electric grid system has grown and evolved. SCADA can give SOs real-time control and visibility over the electric network's information flow. Though NTDC has been using SCADA technology since 1992, many of its essential components are presently non-operational due to a lack of necessary technical hardware and software updates. Operating this vast transmission system with many power-generating plants nationwide without a SCADA system poses significant safety, security, and reliability risks.

NTDC has initiated the SCADA-III project to install the latest hardware and software tools to establish a fully functional system for National Grid operations and monitoring. The timely implementation of SCADA-III is crucial, especially considering the anticipated expansion of the power system and its operational requirements.

- A data exchange portal is also necessary!

Having SCADA in place is crucial for making efficient operational decisions and keeping track of logged data. Although SCADA systems can detect if a unit is out of sync with the grid, they cannot determine if it is on standby or undergoing a scheduled or forced outage. In such cases, a data exchange portal becomes necessary to record the required information.

Adding HVDC transmission lines can reduce the power system losses and improve stability significantly. Serious planning must be in place for the maximum utilization of any new facility.

- Intelligent Power Network Stability systems with reliable telecommunication media must be installed to replace the outdated under/over frequency schemes.

Furthermore,

- A comprehensive analysis of power system planning studies, substation and transmission line constraints, and system stability is necessary to prioritize and tackle significant equipment replacement work, extension requirements, and rehabilitation efforts.

- Redesigning transmission systems to incorporate ring-main systems, which were not present in the previous system, can help to enable targeted shutdowns in affected areas without disrupting the entire system.

- Efficient asset management in the power industry requires an understanding of available techniques and a progressive development approach. Decision-makers must plan meticulously with short-term, mid-term, and long-term plans in place.

- By adhering to high standards and leveraging technological advancements, the planning process at NTDC can become instrumental in shaping the future of Pakistan's energy landscape.

Fostering resilience, reliability, and sustainability in power transmission infrastructure is crucial for the country's development. Acquiring equipment and services, both consulting and non-consulting, is a significant part of the NTDC budget; addressing underlying issues is essential to ensuring continuous process improvement.

A robust governance structure is necessary if an organization aims to achieve technology adoption, innovation, and operational efficiency. Without it, the chances of success in these areas are significantly lower.

Governance, Corporate Governance, and Transparency

NTDC is participating in international benchmarking programs and collaborating with other transmission companies to exchange best practices and improve performance.

NTDC has successfully implemented an Enterprise Resource Planning (ERP) system, a software that helps manage business tasks and processes smoothly and prevents delays. The software handles file delays, streamlines business operations, and ensures smooth workflows. It's crucial to avoid minor delays from snowballing into more significant problems like starting or completing a transmission line. NTDC is one of the pioneers in adopting this cutting-edge ERP system.

Again, these steps would be meaningless without a complete overhaul of the NTDC's governance structure: Decentralization of power for better management and decision-making is required. Make the organization accountable for its operational and financial decisions.

- An independent and non-political board of professional directors specialized in the power sector should be appointed to develop a business model and effectively run NTDC by selecting competent management.
- The board members must meet the criteria specified in SECP guidelines and receive appropriate training to qualify as independent directors. Once appointed, the board should have the power to make tough decisions and be held accountable.
- It is better that experts nominated by Parliament, or its committee make board appointments rather than the PD, which is influenced by politicians.

Professionals possess the skills to drive progress, while bureaucrats or political appointees lack an understanding of sector complexities. Establishing NTDC as an independent entity based on corporate principles is necessary for success.

- Professional management with a vision and a business plan focused on commercial success is essential for NTDC.

- Boards should appoint a professional Managing Director and senior management on merit. These professionals must be empowered to act independently without any political influence and must be able to make critical decisions.

- Holding management accountable for wrong decisions is crucial, and it is the responsibility of the independent board to hold them responsible.

The MD of NTDC oversees the company's operations to meet its service and revenue targets.

- The MD must establish goals and develop plans prioritizing network and service improvements. He/she must also ensure that the company complies with regulatory and operational requirements and understands national policies well. For this, consistency in his job tenure and his appointment on merit are compulsory.

- A competent and apolitical MD and senior management must be appointed for a certain period with clear targets and a market-based salary linked to the targets and the organization's profitability.

To achieve performance targets, NTDC requires competent professionals with proven leadership, communication, and interpersonal skills in every department.

For NTDC to succeed as an effective National Grid Company and as an effective System Operator, an unprofessional bureaucracy must stay out of their managerial and financial affairs.

- NTDC must enhance its professional and institutional capacity by launching a formal research and development (R&D) component.

NTDC should encourage its professionals to contribute to this initiative proactively. It is vital to prioritize training and capacity building specifically for system operation staff at NPCC to minimize EMO violations.

Improving coordination among functional departments, assigning dedicated project managers, implementing enhanced project management practices, and establishing Project Management Offices (PMOs) and Standard Operating Procedures (SOPs) are all the initial steps towards the NTDC reform process. Innovative thinking, proactive problem-solving, and efficient processes can significantly improve its performance in all its functions.

NTDC must have a well-designed and regularly updated website to increase transparency and accountability. Its annual reports and financial statements should also be timely available for public scrutiny.

Financial Security

NTDC must carefully manage its finance costs to mitigate financial risks and maintain financial stability. This may involve optimizing its debt structure, refinancing debt at favorable terms, exploring alternative financing options, and implementing cost-saving measures.

- To improve NTDC's financial health, debt management strategies that reduce the company's debt burden may be necessary. For instance, refinancing the existing debt at lower interest rates or implementing cost-saving measures to improve profitability and generate cash flow.

- To increase equity financing, it is important to have NTDC's disclosure on the stock market.

    - Institutional investors (such as mutual funds or pension funds) should be allowed to control and run the business rather than depending on loans for investments.

    - NTDC must have a sustainable business model to attract investors

Tariff variations can cause financial insecurity and operational inefficiencies, affecting stakeholders and consumers. To mitigate these effects,

- It is necessary to simplify review procedures, ensure transparent communication, and conduct predictive market analysis.

These steps can ensure timely adjustments and foster stability in the energy market. The complexity of the revenue requirement formula may pose practical challenges and lead to discrepancies in cost allocation.

Despite significant overall funding, regional disparities in investment often result in unequal development and infrastructure inadequacies, affecting reliability in specific areas. This approach needs to be reconsidered.

The impact of relying heavily on regulatory decisions to determine tariffs cannot be understated. Delays and uncertainties can significantly impair market predictability, which may have far-reaching consequences. It's time to reconsider this approach and find more effective solutions to create a stable

and predictable business environment in the power sector.

NTDC must ensure a well-structured governance set-up and long-term financial stability to ensure the timely completion of under-process projects as per the design and achieve the performance level per NEPRA-specified performance standards.

Temporary or stop-gap solutions in the power sector can lead to long-term instability and financial unfeasibility. The NTDC must prioritize long-term resilience and economic stability for a thriving power industry and adopt a forward-looking approach.

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Appendix A. List of MD since 2012

Sr. No	Name	From	To	Stay	Nature of Appointment
1	Rasul Khan Mahsud	26/06/2011	27/06/2012	1 year & 3 months	Internal (contract)
2	Naveed Ismail	04/07/2012	31/10/2012	3 months & 28 days	External (stop-gap basis)
3	Mussadiq Ahmed Khan	01/11/2012	13/03/2013	4 months & 13 days	Ministry (stop-gap basis)
4	Khalid Hussain Rai	13/03/2013	07/05/2013	1 months & 26 days	Internal (stop-gap basis)
5	Zargham Eshaq Khan	08/05/2013	24/06/2013	1 months & 17 days	External (stop-gap basis)
6	M. Zia-Ur-Rehman	24/06/2013	28/03/2014	9 months & 5 days	Internal (stop-gap basis)
7	Tahir Mahmood	28/03/2014	30/01/2015	10 months & 3 days	Internal (stop-gap basis)
8	M. Arshad Chaudhary	02/02/2015	04/07/2016	1 year 5 months & 3 days	Internal (stop-gap basis)
9	Dr. Fiaz A. Chaudhary	15/07/2016	07/07/2017	9 months & 24 days	External (contract)
10	Zafar Abbas	07/07/2017	31/07/2018	1 year & 25 days	Ministry (stop-gap basis)
11	Dr. Amer Ahmad	01/08/2018	19/09/2018	1 months & 19 days	Ministry (stop-gap basis)
12	Zafar Abbas	19/09/2018	29/04/2020	1 year 7 months & 11 days	Ministry (stop-gap basis)
13	Dr. Khawaja Riffat Hassan	29/04/2020	20/05/2021	1 year & 22 days	Internal (stop-gap basis)
14	Muhammad Ayub	20/05/2021	04/08/2021	2 months & 16 days	Internal (stop-gap basis)
15	Azaz Ahmad	04/08/2021	03/11/2021	3 months	External (contract)
16	Manzoor Ahmad	15/11/2021	14/05/2022	6 months	Internal (stop-gap basis)
17	Dr. Rana Abdul Jabbar Khan	07/07/2022	06/01/2023	6 months	Internal (stop-gap basis)
18	Dr. Rana Abdul Jabbar Khan	09/02/2023	15/04/2024	1 year 2 months & 7 days	Internal (contract)

Source: Bifurcation of NTDC: A Flawed Plan? Business Recorder, July 09, 2024. Available at https://www.brecorder.com/news/40311874/bifurcation-of-ntdc-a-flawed-plan

Endnotes

1. In 2021, an 886 km HVDC transmission line was constructed to transport electric power more efficiently from the southern region to the central and northern load centers. The line has a capacity of 4,000 MW. However, the line is being underutilized. In FY2023, the average utilization of this vital infrastructure was only 39.6% of its designed capacity. The company constructed has a take-or-pay contract, which means they are entitled to receive payment for the full capacity, even if it is not fully utilized. This situation is negatively impacting the power sector and placing an additional burden on electricity consumers. Several contributing factors include inadequate AC systems at the receiving end and negative sales growth.

2. NEPRA allows frequency variations of ± 1% of the nominal frequency of 50 Hertz, meaning the frequency should remain within the range of 49.50 to 50.50 Hertz. The criteria for reporting frequency variations outside these limits only apply when the duration of the variation exceeds a continuous period of five minutes.

3. Performance Standards (Transmission) Rules, 2005.

4. Determining TOU tariff is not the domain of NTDC.

5. Although gas allocation is not directly the responsibility of the SO, efficient plants often remain offline due to the non-availability of LNG/gas, while inefficient GENCOs are allowed to operate, increasing the energy cost for the end consumer.

6. Some of the information in this section is cited from Cheema et al. (2022).

7. Same approach in the procurement process as discussed in the previous subsection.

8. NTDC financial account statements since FY2014 are publicly available. These statements have been audited by M/s. Grant Thornton Anjum Rahman (Chartered Accountants) since 2017. Before FY2017, the audits were conducted by KPMG Taseer Hadi & Co., Chartered Accountants. As stated in the audited review for FY2023, the review is primarily limited to inquiries of the company's personnel and review of various documents prepared by the NTDC to comply with the rules.

9. Fluctuations in finance costs are due to interest rates, debt portfolio, refinancing, rising rupee-dollar parity, and the economy.

10. National Transmission and Dispatch Company (NTDC) has been a significant recipient of donor loans in the energy sector. As per the information available on WB and ADB websites, in the past two decades, the Asian Development Bank (ADB) provided loans totaling US$2.5 billion for various transmission enhancement projects that have been completed or are currently ongoing. The World Bank (WB) also provided US$682 million for similar projects.

11. The debt-to-equity ratio measures a company's debt relative to equity. For NTDC, debt includes interest-bearing liabilities such as long and short-term debt, leases, and other periodic interest payments. Equity comprises common stock, retained earnings, and additional paid-in capital.

12. It is an issue, as informed by NTDC officials.

13. The most recent data available is for FY2022.

14. This may include the cost of committee meetings, as breakup of meeting fee is not available. It is assumed that committee meetings follow the full board meetings.

15. Appointed against the criteria of SECP.

16. Cited from Cheema et al. (2022).

17. More than 32% of total employees are support staff (BPS-1 to BPS-6).

18. NTDC employees shared these observations/ examples as they expect the same at NTDC.

19. Although (as mentioned in previous sections) its underutilization is a burden to consumers due to a take-or-pay contract with the constructing company.


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