

Majors: FIN

Major/No. (F10)

**Projections Of Power Purchase Price Report Leading to Fuel Cost Adjustments
(FCA)**



By:

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Bahria Business School

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TO WHOM IT MAY CONCERN

This is to certify that Syed Wajahat Ali bearing CNIC No. 61101-7744490-5 has been employed with the National Electric Power Regulatory Authority (NEPRA) as "Assistant Director" in the Technical Department since September 30, 2021.

2. He is currently undertaking his Final Year Project titled "Projections of Power Purchase Price Report Leading to Fuel Cost Adjustments (FCA)" by Syed Wajahat Ali (01-322241-023), submitted in partial fulfillment of the requirements for the degree of Master of Business Administration (MBA) from Bahria University, Islamabad, Pakistan during the academic year 2025. This project is a bona fide record of work carried out with the permission and guidance of NEPRA.

3. This certificate is issued upon his request without any liability on the part of NEPRA and solely for the purpose it purports to serve.

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ABSTRACT

This paper details the design and application of the Power Purchase Price (PPP) forecasting model which aims at improving the predictability of tariffs and lessening the impact of Fuel Cost Adjustment (FCA) fluctuation in Pakistan electricity sector. The growth in the cost of power purchasing, lack of regularity in the tariff adjustments, and the constant mounting consumer challenge coupled with external shocks like depreciation of the currency, changes in fuel prices, the variability in hydrology and the rising circular debt all point to the extreme need of a data-driven forecasting projection. In the analysis of the future PPP values, employing the historical PPP records, scenario modelling, sensitivity analysis and performance variance analysis, the study develops a multi-layered analytical model, which is able to project faithfully the future PPP values and correlate them with the NEPRA tariff requirements. Close correlation between the values projected and actual PPP was observed because of pilot testing during selected months, and this creates high reliability and low variance. Sector-wide issues of operation, such as the weaknesses of governance, slowing of tariff determination, reliance on fuel, high T and D losses, ineffective recovery of costs, and inconsistency of regulatory data, are also measured in the study. To address these concerns a holistic improvement plan was created, including privatization models, internal process restructuring, integration of advanced analytics, automation of activities digitally, and cross-institutional synergy between CPPA-G, DISCOs, ISMO, and NEPRA. Liquidity, profitability, asset efficiency, leverage, and the ratio of returns can be improved in the financial and statistical analysis, which indicates that the planning enhancement through the PPP can be used to significantly increase financial sustainability. The paper finds that when institutionalized and constantly improved, PPP forecasting can provide a revolutionary mechanism to stabilize tariffs, decrease FCA burdens, and improve sector transparency and reduce the circular growth of debt, which, in the end, will increase consumer confidence and economic stability. This framework offers a viable way of achieving efficiency in long-term planning and financial recovery to policymakers, regulators and utility managers.

Keywords: *Power Purchase Price, Fuel Cost Adjustment, NEPRA, CPPA-G, tariff forecasting, circular debt, hydrology, dispatch planning, operational efficiency, privatization, data analytics, financial sustainability, Pakistan power sector.*

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Chapter 1

INTRODUCTION

1.1 Background

Over the past years, the power industry in Pakistan has been encountering increasing challenges due to the macroeconomic instability, the increase of inflation, and the instability in the global fuel markets (Hussain, Ahmed & Qazi, 2021). These issues have influenced the cost of generating electricity that is transferred to the final consumers in terms of electricity tariffs. The large and sometimes significant changes in FCA have led to significant increases in electricity bills and this has burdened households, commercial users and industrial consumers in the country with a huge financial weight (Zubair, 2024).

The electricity bills in Pakistan have demonstrated the extensive changes every month in the past one year; there have been positive and negative FCAs that are equally enforced in the whole country except the K-Electric system. Although FCAs are a valid regulatory instrument with the aim of cost recovery and financial sustainability of the power sector, they have been very uncertain, thus causing confusion and dissatisfaction and growing public mistrust about the regulatory process and National Electric Power Regulatory Authority (NEPRA). These adjustments are perceived by consumers as being arbitrary, even when they have a technical and regulatory basis, in large part due to the lack of transparency and poor correspondence between projected and actual costs of generation (Rafiq, 2025).

One of the aspects that have been causing FCA volatility is the erroneous or skewed projections of Power Purchase Price (PPP). Power Purchase Price is the general cost of electricity at which Central Power Purchasing Agency (Guarantee) Limited (CPPA-G) buys the electricity produced by the generation companies. The projections are the foundation of reference fuel costs on which NEPRA has been basing tariffs. Nonetheless, the power market in Pakistan has a high dynamic environment due to the unstable international fuel prices, depreciated exchange rate, inflationary pressures, seasonal hydrological changes and the changing demand pattern of electricity. In cases where these factors are not sufficiently reflected in PPP forecasts, there would be a high deviation between the forecasted and actual costs, thereby leading to an increase in FCAs in the following billing periods (Qureshi, 2023).

Here, consolidation of methodology and strength of PPP estimates to be applied in setting regulatory tariffs is desired. To minimize the occurrence and severity of FCAs, improving the accuracy of the forecasts will reduce the frequency and severity of tariff forecasts, and consumer trust in the regulations system. The more transparent, data-driven, and scenario-based method of PPP forecasting will not only assist in the fair price of electricity but also lead to the financial sustainability and efficiency of the Pakistani power sector over the long run (Danish, 2022).

1.2 Strategic Importance

This project is also strategic because it will directly help in enhancing the stability, transparency, and sustainability of the Pakistani power sector by increasing forecasting of Power Purchase Price (PPP). Electricity pricing is a decisive variable of economics that impacts households, businesses and competitiveness in industries. Regular and unforeseeable Fuel Cost Adjustments (FCA) in Pakistan have imposed financial pressures on consumers and uncertainty on a business, not to mention causing a lack of trust between the people and the regulatory bodies. This project will deal with a fundamental structural deficiency that provides tariff volatility by enhancing the PPP projections (Rameez, 2022).

Proper PPP forecasting is strategically significant to the effectiveness of regulatory powers (Iqbal, Sohail & Danish, 2025). The National Electric Power Regulatory Authority (NEPRA) has been relying on the projections of PPP reference provided by Central Power Purchasing Agency Limited (CPPA-G) as a reference in determination of tariff. In cases where these projections do not well represent the realities of the market like the fluctuation in fuel prices, changes in the exchange rate, hydrological variability and change in demand, the tariffs vary with the real-life costs. The consequence of this misalignment is the repeated ex-post repricing of the process of determining the tariffs with the use of the FCA, which undermines the credibility of the process of determining the tariff (Rasheed, 2023).

Institutional and financial sustainability the project, in its turn, facilitates the significant role of CPPA-G in the settlement of the power sector. Enhanced PPP forecast cuts down forecast errors that lead to cash flow discrepancies, payments delays, and financial strain throughout the power chain of values. The project will help the generation companies, distribution companies, and central purchasers to improve financial discipline by allowing a better alignment of projected and actual costs, which, in turn, helps to reduce systemic risk in the sector (Khattak, 2022).

The project is also strategic in the welfare of the consumers and confidence of the population. Clear and foreseeable prices of electricity lead to greater knowledge and acceptance of tariffs by consumers. Social resistance to tariff reforms decreases when consumers can predict change and have confidence in the regulating process. By so doing, the project is not only working on technical and regulatory enhancement, but long-term sector reform facilitating accountability, transparency, and sustainability in the Pakistani power sector (Kazmi, 2025).

1.3 Project Rationale

The argument supporting this project is that the power industry of Pakistan is increasingly experiencing financial, regulatory and social pressures especially with respect to the fluctuation of electricity tariffs and the affordability of the consumers. With the current inflationary environment, depreciation of exchange rates and uncertainty in prices of fuel all over the globe, electricity consumers in Pakistan have been faced with a tremendous rise in their monthly electricity bills. One of the leading causes of such instability is the frequent use of Fuel Cost Adjustments (FCA) that commonly change significantly every month (Latif, 2021).

Nevertheless, the environment in which the power sector in Pakistan works is highly dynamic as it depends on the changes in the international fuel prices, inflation, exchange rates, increasing demand, and weather changes. Their insufficient integration into PPP predictions causes the variance of reference and actual costs that subsequently get accounted back by FCAs imposing an extra burden on the consumers. This project is thus necessitated by the business need to increase the accuracy, strength, and transparency of PPP forecasting. Scenario-based projection framework, which is a data-driven model, can enhance the correspondence of projected and actual costs, thus lessening the scale and frequency of FCAs (Saeed, 2023).

This project will make national policy goals regarding energy sector reform, financial discipline, and economic stability directly because it enhances PPP projections (Sohail, 2025). Finally, the project aims to contribute to more predictable tariff regime, credibility, and an efficient, transparent, and competent power sector that can contribute to the long-term economic growth of Pakistan (Hasan, 2023).

1.4 Project Purpose

This project aims at enhancing the affordability and predictability of electricity tariffs in Pakistan by enhancing the precision and reliability of the Power Purchase Price (PPP) projections. The

unstable fuel prices and poor forecasting habits have led to Frequent Fuel Cost Adjustments (FCA) that have heightened the financial strain on the consumers. The objectives of this project are to promote the transparency and efficiency of the regulation by creating a data-driven forecasting model, which would capture the actual dynamics of the market, such as the fuel prices, the exchange rates, the hydrology, and the fluctuating demand. Using the suggested framework, CPPA-G can assist NEPRA in making more precise predictions of PPP, which will result in equitable decisions on tariffs and a higher level of stability in the sector.

1.5 Industry Analysis

The power sector has always been perceived in Pakistan as a means of economic growth, industrialization and social welfare. The electricity sector in the country has been developing since the period of independence in August 1947 with the increasing population, urbanization and increasing industrialization. When Pakistan became independent, the installed electricity generation capacity was around 60 megawatts (MW), and this was able to serve little commercial and residential use. Nevertheless, the growing economic activity then led to the rapid increase of the demand in the stable and affordable electricity, which means that power sector had to be constantly extended and re-sized (Younis, 2025).

Pakistan was making tremendous strides to improve its generation capacity during the first few decades of independence especially starting in the 1970s. At this time, installed capacity had risen to almost 600 MW because of the rising energy demands of the industrial and manufacturing industries. Much emphasis by the government was on development of hydropower resources with the help of the natural river systems in the country. Consequently, significant hydro power projects were launched and the generation capacity increased significantly. The installed generation capacity of Pakistan was so high by the end of 1990 that it reached about 9,000 MW, and hydropower took a significant part in the energy mix (Riaz, 2024).

Regardless of these expansions, the demand and the lack of resources in the public sector led to the turn in policy in favor of involvement of the private sector. To overcome generation deficits and attract investment, the government produced the Power Policy of 1994, with the formal incorporation of Independent Power Producers (IPPs) into the power industry. This policy made major changes to the industry structure by promoting the course of power generation privatization. The further policy, such as the Power Policy of 2002, the Renewable Energy Policy

of 2006 and the Power Policy of 2015, followed the same pattern, increasing the involvement of the private sector and diversification of the energy mix (Kamal, 2025).

These reforms have enhanced installed capacity and enhanced availability of supply but have also come with new challenges concerning cost recovery, tariff setting and financial viability. In the context of this changing industry environment, Power Purchase Price forecasting has assumed more importance to effective regulation and the stability of the sector in the long term (Fayyaz, 2024).

As on 30 th June	2020	2021	Variation	
			Capacity	%
A. CPPA-G SYSTEM				
WAPDA Hydel	9,389	9,443	54	0.57
IPPs Hydel	472	472	0	0.00
Total: Hydel	9,861	9,915	54	0.54
GENCOs	4,881	4,881	0	0.00
IPPs	17,276	17,276	0	0.00
SPPs/CPPs	340	340	0	0.00
Nuclear	1,330	2,475	1,145	86.10
Total: Thermal including Nuclear	23,827	24,972	1,145	4.80
Wind	1,248	1,248	0	0.00
Solar	430	430	0	0.00
Bagasse/Biomass	369	369	0	0.00
Total: CPPA-G System	35,735	36,934	1,199	3.36
B. K-ELECTRIC SYSTEM				
KE Own	2,294	2,084	-210	-9.15
IPPs	366	366	0	0.00
SPPs/CPPs	87	151	64	73.56
KANUPP	137	137	0	0.00
Solar	100	100	0	0.00
Total: KE System	2,984	2,838	-146	-4.89
Grand Total: Installed Capacity of the Country	38,719	39,772	1,053	2.72

Figure 1: Installed Capacity (Source: NEPRA SIR Report 2021)

1.6 Potential Risks

Though a structured methodology and data-driven approach was used in the given project, a number of risks could have an influence on the precision and consistency of the Power Purchase Price (PPP) projections. One of the significant risks is exchanging rate volatility because the power sector of Pakistan relies on imported fuels especially coal and RLNG. Any sudden decline in the Pakistani Rupee value will raise fuel acquisition prices and cause big disparities between estimated and real PPP values. The other major risk is the delays in the commissioning of the new power plant. When the planned facilities are not completed on time or are not used with the

expected efficiency, the real mix of the generation can switch to the more expensive sources, which will result in a higher final-buy price.

This is also critical to fuel price instability. Geopolitical uncertainty, disruption of supply or fluctuation in demand in world energy markets could result in sudden alterations in PPP results and cause unforeseen FCA changes. There is hydrological uncertainty that presents other issues. Water supply may decline which will reduce the low-cost hydropower production and lead to high reliance on thermal power plants.

Additionally, changes in policy and regulations can modify pricing arrangements, cost recovery policies or subsidy programs, which can affect the accuracy of PPP. Lastly, underlying assumptions can be distorted by macroeconomic shocks, including the increase in inflation or drop in electricity demand. These dangers support the significance of scenario modelling and regular evaluation of forecasts.

1.7 Significance of the Study

The research is important because it has been conducted to enhance efficiency, transparency, and sustainability of the power industry in Pakistan in terms of better forecasting of Power Purchase Price (PPP). Pricing electricity is a very essential concern to the Pak economy because it directly impacts the welfare of the households, industrial competitiveness, and the economy in general. The constant change in electricity tariffs, especially by use of Fuel Cost Adjustments (FCA), has added financial uncertainty to both the consumer and the business. One of the major structural reasons of such volatility is the subject of this study that dwells upon a problem of the accuracy and resilience of PPP projections, which are utilized in the determination of regulatory tariffs.

Regulative, the research is important in that it assists in evidence-based decision-making by the National Electric Power Regulatory Authority (NEPRA). Enhanced PPP forecasting gives a more accurate and justifiable foundation on which to set tariffs, eliminating the need to use the ex-post approach and enhancing regulatory integrity. Clear and properly recorded projections will also boost confidence of the stakeholders in the process of the tariff determinations and will help create a more reliable result in the electricity prices.

To institutional stakeholders, especially Central Power Purchasing Agency (Guarantee) Limited (CPPA-G) the study will enhance planning and compliance abilities. Sound PPP projections

enhance financial forecasting, minimize settlement disparities, and enhance improved coordination with generation businesses, distribution businesses, and system operators. This helps in management of cash flow and minimizes systemic financial risk in the power sector.

The research also has good economic and social relevance. Electricity tariffs like electricity prices are predictable, which is a requirement to the planning of industries, investment and competitiveness of exports. The study helps the Government of Pakistan in achieving its policy goals as regards to ease of doing business, industrial growth, and economic development because it helps to reduce the volatility of tariffs. To consumers, the open and reasonable changes in tariffs increase curiosity and toleration of electricity bills and lessen the opposition and discontent of the population with the changes required in the sector.

The academic implication of the study is the application of the research in applied research in the fields of energy economics and regulatory policy by showing that scenario-based forecasting is a practical tool in determination of tariffs. The research is meaningful towards making electricity market in Pakistan more dependable, consumer-friendly and financially sustainable.

Chapter 2

PROBLEM DEFINITION AND REQUIREMENT ANALYSIS

2.1 Identification of the Core Business Problem

The business issue in this project is past imprecision and discrepancy in the forecast of Power purchase price (PPP), resulting in regular and unpredictable Fuel Cost Adjustments (FCA) in power charges in Pakistan. The cost element that the national electric power regulatory authority (NEPRA) relies on when determining the tariffs on electricity is Power Purchase Price. In the case where PPP forecasts are not true measures of market and system conditions, the difference between projected and achieved costs is offset by ex-post changes, which have direct effects on consumers and market stability (Irfan, 2023).

In the last few years, the Pakistani electricity consumers have been facing steep rates of the monthly changes in electricity bills and FCA values have been going up and down. Such differences have caused confusion, dissatisfaction and an increasing level of distrust by people in the regulatory framework. Although FCA is a self-justified system that aims to recover costs, its extensive use reflects the flaws of long-term cost forecasting, and not inefficiencies in the correction system (Anjum, Rehman & Nisar, 2021). It is not the existence of FCA that is a problem, however, but over-reliance on FCA as a corrective measure, because of incorrect PPP forecasting (Salman, 2024).

As a strategic matter, erroneous PPP estimates deter tariff predictability as well as price signals to industry and investors. The unpredictable power prices deter the growth of industries, make business planning difficult and undermine the intentions of the government to introduce easy-to-do business. In addition, the recurrent process of tariff changes undermines the integrity of the regulatory bodies and heightens the opposition to the required sector changes (Azeem, 2021).

The fundamental issue of business is that there is a system-wide forecast deficit, which correlates technical flaws in PPP estimates to larger financial, regulatory, and social impacts. To solve this issue, it is necessary to shift to a more robust, data-driven, scenario-based cost forecasting model that would align the projected costs with the reality of the market and be able to support a stable, transparent, and sustainable system of electricity prices (Zameer, 2025).

2.2 Projections of Power Purchase Price

Considering the power sector in Pakistan, prediction of Power Purchase Price (PPP) is at the heart of the determination of power tariffs as well as the financial sustainability of the industry. Power Purchase Price is the average price of electricity at which Central Power Purchasing Agency (Guarantee) Limited CPPA-G buys electricity at a price average that is applied to all the public and private generation companies. The projections are the reference fuel costs relied upon by the National Electric Power Regulatory Authority (NEPRA) when determining the tariffs (Hassan, 2023).

To overcome these uncertainties, the development of PPP projections in Pakistan is based on scenario approach. CPPA-G simulates various cases with various assumptions on electricity demand development, fuel prices, exchange rates, hydrological situations and activeness of new generation capacity. These cases allow regulators to evaluate a variety of costs and choose reference values that will most effectively combine financial feasibility and consumer affordability. The application of scenario analysis is associated with an understanding that one-point projections cannot be used when there is a high degree of volatility in the operating environment (Sohail, 2021).

Demand projections are also not negligible in the PPP forecasting. The macroeconomic growth, industrial activity, weather conditions and trends in energy efficiency determine electricity demand in Pakistan. The demand may be overestimated or underestimated and may change the dispatch patterns which influence the cost of power procurement. Accordingly, the PPP forecasts are based on the demand conditions, supported by the past consumption rates, macroeconomic factors, and consultations with stakeholders (Sultan, 2020).

The reference fuel costs in the regulatory system of Pakistan are calculated by using projected values of PPP and the difference between the projected and actual costs is compensated by Fuel Cost Adjustments (FCA). Whenever the projections are close to the actual outcomes, the value and occurrence of FCA are lower and electricity bills become more foreseeable. Thus, to enhance the degree of tariff stability, regulatory transparency, and consumer confidence, the PPP projections are to be empowered. To conclude, strong PPP forecasts would be a strategic resource in realizing a more efficient, transparent and sustainable electricity pricing system in Pakistan (Tariq, 2023).

2.3 Scenarios for Power Purchase

To report the uncertainty that is inherent in the power sector of Pakistan, five different scenarios have been made to project the Power Purchase Price (PPP) references of the Calendar Year (CY) 2026. These cases are meant to reflect the possible fluctuation in the electricity demand of key cost drivers' electricity, exchange rate, hydrology and fuel prices that are used to establish the cost of power procurement by Central Power Purchasing Agency (Akram, 2025).

The base case is normal electricity demand, average exchange rate of PKR 290-300/ USD, normal hydrology and normal fuel prices. The situation described is the most probable one according to the former trends and the modern market demands. It acts as the reference point against which the effects of the other scenarios are compared, and it gives NEPRA the center point of determining tariffs (Jamal, 2024).

The scenario is the demand high electricity demand which is an indicator of better than projected economic activity or extreme weather circumstances. Demand is taken as being higher than the normal demand, with no change in exchange rates, hydrology, fuel prices. This case study evaluates the impact of the higher load of systems on the dispatch of generation, fuel usage, and the mean price of power purchasing (Fazal, 2022).

The situation analyses the impact of the high fuel prices, especially on imported coal and RLNG. In this case, the fuel prices are set to rise above the normal price and demand, exchange rates and hydrological conditions are held constant. This situation sums up energy market shocks all over the world and how they were directly passed on to the home electricity prices (Rasheed, 2021).

Taken together, these scenarios give NEPRA and CPPA-G a robust and holistic approach to PPP forecasting, which allows to make informed regulatory decisions and minimize tariff volatility in the electricity sector in Pakistan (Naveed, 2024).

Table 1: Scenarios for Power Purchase Price (PPP) Forecast – CY 2026

Scenario	Demand	Exchange Rate (PKR/USD)	Hydrology	Fuel Prices
1	Normal	290 / 300	Normal	Normal
2	Normal	300 / 310	Normal	Normal
3	High	290 / 300	Normal	Normal
4	Normal	290 / 300	Normal	High
5	Normal	290 / 300	Normal	Low

2.4 Assumptions for Power Purchase Price (PPP) Projections

The Power Purchase Price (PPP) projections of the Calendar Year (CY) 2026 are prepared on all-inclusive technical, economic, regulatory, and system-level assumptions. These assumptions give a systematic basis to the scenario-based projections and assure uniformity, openness and correlation with the already established power sector framework in Pakistan. Since the electricity market is dynamic in nature, the assumptions are made realistic though sufficient flexibility is provided in the assumptions to capture the uncertainty.

1. Electricity Demand Assumption: The demand forecasts for electricity are premised on the past consumption patterns, with a modulus on the projected economic growth, population growth, variability of weather, and industrial activity. There are two demand conditions which are considered, and they are normal demand and high demand. Normal demand is the average historical growth trends given by the Independent System and Market Operator (ISMO) and a high demand is when there is rapid economic activity, heat waves or industrial usage 2026.

2. Exchange Rate Assumption: Exchange rate is a crucial factor of PPP because Pakistan depends on imported fuels and capacity payment in the form of foreign currencies. The forecasts are based on a range of exchange rates of PKR 290 to PKR300 against USD in normal situations and PKR 300 to PKR310 against USD in the case of depreciation. These estimates are informed by the existing macroeconomic indicators, beliefs of IMF and the current market trends. The assumption is that there is no extraordinary currency stock in the outside range of scenarios.

3. Assumption in Hydrology: Hydrology is assumed to be normal in all cases, depending on long-term average data of water inflow in major dams like Tarbela and Mangla. Normal hydrology suggests that there is average access to cheap generation of hydropower all year round, with no major drought or excessive floods. This is since this assumption allows the isolation of the effect of demand, fuel prices and exchange rates on PPP and holds the hydrological variability constant.

4. Fuel Price Assumption: Fuel prices are assumed in three conditions normal, high and low. Normal fuel prices are pegged by existing international standards and regulatory reference prices to imported coal, RLNG, furnace oil and domestic gas. High and low fuel price assumptions represent conceivable increases or decreases in world energy markets because of geopolitical events, supply shocks or shifts in demand. It is believed that procurement of fuel is done in a manner that is in accordance with the various existing contractual matters and mechanisms of price.

5. Generation Fleet and Capacity Assumption: The estimates assume that the current generation fleet is running based on the reported capacities, heat rates, availability factors and efficiency parameters. The assumed working power plants will all be still running by CY 2026. New power stations are supposed to be commissioned within the planned schedules without any major delays or cancellations. There are no significant forced outage or permanent retirements of plants assumed other than historical averages.

6. System Dispatch and Merit Order Assumption: Dispatch of power systems is thought to be based on the least cost merit order, where there are technical limitations and fuel is available. The less expensive sources of generation, such as hydroelectric generation, nuclear generation, and efficient thermal generation, are turned on in advance of the higher-cost generation. The transmission constraints are assumed to be kept at manageable levels and are not distorting dispatch results in a material manner.

7. Regulatory and Policy Framework Assumption: It is assumed that the current regulatory system that has controlled tariff setting, changes in fuel costs, and cost pass-through will not change in CY 2026. The methodology adopted by NEPRA in determining PPP references and calculating the FCA is supposed to remain as it is already being practiced and there are no significant policy or regulatory shocks.

8. Macroeconomic Stability Assumption: It will assume that macroeconomic factors including inflation, interest rates, and GDP growth would follow the forecasts provided by credible institutions, including the IMF and State Bank of Pakistan. Extreme macroeconomic shocks are not postulated outside those which are defined in specified scenarios.

These assumptions together give a practical and clear basis for projecting Power Purchase Price. They permit CPPA-G and NEPRA to evaluate the results of potential costs in different conditions without losing analytical rigor and regulatory consistency.

2.5 Fuel Cost Adjustments (FCA)

The Fuel Cost Adjustment (FCA) is a regulatory process applied in the electricity billing expansion of Pakistan to reflect the discrepancy amid the real fuel cost and the reference fuel cost taken during the establishment of tariffs. FCA is used to make sure that the cost related to fuel aspects are allowed by legitimate expenses incurred by the power sector because of fluctuations in the prices of the fuel used, generation mix, exchange rates, and system dispatch (Khalid, 2023).

Pakistan Electricity tariffs are normally determined using estimated costs, comprising of an assumed fuel price and generation mix. Nevertheless, because of the fluidity of the power industry, that is, the changeable international fuel prices, variances in the exchange rate, and seasonal changes in hydropower generation, the reality of the cost at which they produce electricity is usually at variance with these estimates. FCA intends to deal with this gap by enabling the utilities to recover the difference between the anticipated and actual costs of fuel, by imposing a fee on the consumers or in some instances, by making a counterbalancing adjustment.

The size of FCA in Pakistan has grown over the past few years because of the increasing prices of global fuel, depreciation of Pakistani rupee, as well as increased dependence on imported fuels like coal and re-gasified LNG. The FCA values have soared during the fuel price spikes, currency depreciation forcing them to pay a lot more in electricity bills, and the combination has put the households, commercial users, and industrial consumers under financial strain. On the other hand, the negative FCA values have been taken in times of low fuel prices or increased supplies of hydropower, which have only offered some temporary relief to consumers (Zahid, 2025).

Although FCA has a significant purpose in ensuring the financial sustainability of the power industry, its frequent and irregular use has created a popular panic. FCA is also viewed by many consumers as a black box and hard to comprehend, which serves as the cause of mistrust in the billing system and the regulatory process. This highlights the need to make greater enhancements in Power Purchase Price (PPP) forecasting because, with more precise projections, the difference between reference and actual costs can be minimized and, consequently, the volatility of FCA is minimized. Pakistan In the Pakistani setting, FCA management is important in ensuring a balance between cost recovery, affordability, and the long-term sustainability of the electricity industry (Naseem, 2023).

Table 2: Fuel Price Assumptions for PPP Forecast – CY 2026

Month	Gas (Rs/MMB TU)	Brent (\$/Barrel)	Importe d Coal API-4 (\$/MT)	Importe d Coal ICI-3 (\$/MT)	Importe d Coal ICI-4 (\$/MT)	Thar Coal (\$/MT)	RFO (\$/MT)	Bagasse (Rs/MT)	HSD (Rs/Litre)
Jan-26	1,225	67	84.6	58	30.7	18.6	461	5,209	276.81
Feb-26	1,225	67	84.6	58	30.7	18.6	461	5,209	276.81
Mar-26	1,225	67	84.6	58	30.7	18.6	461	5,209	276.81
Apr-26	1,225	67	84.6	58	30.7	18.6	461	5,209	276.81
May-26	1,225	67	84.6	58	30.7	18.6	461	5,209	276.81
Jun-26	1,225	67	84.6	58	30.7	18.6	461	5,209	276.81
Jul-26	1,225	67	84.6	58	30.7	18.6	461	5,470	276.81
Aug-26	1,225	67	84.6	58	30.7	18.6	461	5,470	276.81
Sep-26	1,225	67	84.6	58	30.7	18.6	461	5,470	276.81
Oct-26	1,225	67	84.6	58	30.7	18.6	461	5,470	276.81
Nov-26	1,225	67	84.6	58	30.7	18.6	461	5,470	276.81
Dec-26	1,225	67	84.6	58	30.7	18.6	461	5,470	276.81

Source Argus Media, Platts, OGRA, NEPRA & TCEB (2025)

2.6 Organizational Needs Assessment

The organizational requirements of the Central Power Purchasing Agency (Guarantee) Limited (CPPA-G) is directly related to its mandate as the central power purchaser and its regulatory requirements with the National Electric Power Regulatory Authority (NEPRA) through the Power Purchase Price (PPP) projections and Fuel Cost Adjustments (FCA) framework. CPPA-G is central to the operation of the power sector settlement mechanism in Pakistan where power purchase costs must be accurately forecasted to have a proper plan, to meet the regulations as well as to be financially stable throughout the complete electricity value chain (Waseem, 2025).

The creation of a powerful, data-intensive, and transparent system of PPP prognosis is one of the main organizational requirements of CPPA-G (Asif, Baqir and Jamil, 2021). As shown in the scenario analysis and assumptions used in the fuel prices in CY 2026, the cost price of power purchase is sensitive to various variables, which include fuel prices, exchange rates, power demand, and generation mix. In the absence of a systematic forecasting model that incorporates these variables, CPPA-G is exposed to more risks of cost mismatch, which then reflects in up-and-down FCA reallocation. Not only consumers are impacted by such volatility, but it also exerts reputational and compliance pressure on the organization (Shakir, 2022).

According to fiscal management, CPPA-G will need proper PPP forecasts to reduce settlement mismatches and cash flow pressures. Miscalculated projections may cause either under- or over-recovery of expenses, adding to the liquidity constraints and making it more dependent on the short-term corrective action like FCA. An effective forecasting strategy facilitates effective budgeting, payment of generation companies in time and general financial discipline in the industry.

Also, CPPA-G possesses an institutional requirement to increase institutional capacity and analytical potential. The need to comply with growing regulatory pressure and civic responsibility requires scenario-based modelling, systematic description of assumptions, and sensitivity analysis. When such capabilities are developed, the CPPA-G can respond to the issue of market uncertainty in advance and not respond to cost deviations after they take place (Saeed, 2025).

All in all, the needs assessment of the organization shows that tightening the PPP forecasting is not only a technical item that needs to be addressed but also a strategic one by CPPA-G to

address the shortcomings in the process of rendering the power sector more efficient and sustainable in Pakistan (Rashad, 2021).

2.7 System and Regulatory Requirements Analysis

The power sector in Pakistan has a very well-organized and controlled structure that aims at balancing the recovery of costs, sustainability of the sector and protecting consumer needs. In this context, it is the role of the National Electric Power Regulatory Authority (NEPRA) to determine tariffs of electricity, depending on the projected costs with the help of the project submitted by the Central Power Purchasing Agency (Guarantee) Limited (CPPA-G). Consequently, the applicability of the tariff determination is subject to the accuracy, transparency and credibility of the Power Purchase Price (PPP) projections submitted by CPPA-G (Qudoos, 2025).

Another important regulatory requirement is consistency. The projections made by the PPP must comply with the past trends, approaches that have been endorsed and current regulations. Unaccounted abrupt changes in previous forecasts or missing homogeneity in the treatment of elements of costs may undermine regulatory confidence. To achieve this need, the system should use the standardized method of modeling, and it should treat the fuel costs, capacity payments, and variable operating costs equally regardless of the scenario (Zaman, 2025).

Integration of the inputs of several stakeholders in the system is also required since power sector in Pakistan is interconnected. The Independent System and Market Operator (ISMO) provide demand and dispatch information, and fuel cost reference is procured by regulatory agencies like OGRA and international standards. Data on the availability of plants, their efficiency, and the terms of the contract are provided by generation companies, policy guidance and macroeconomic assumptions are offered by government agencies. The effective PPP forecasting needs a coordinated system that holds these inputs into one coherent set of analysis (Shams, 2025).

It is also important to comply with regulatory timeline and documentation standards. The projections of the PPP should be received in time as deemed fit to facilitate the tariff procedures during a given financial or calendar year. Sluggish or incomplete documentation has the potential to disrupt the tariff determination processes and augment the use of ex-post arrangements like Fuel Cost Adjustments (FCA). Accordingly, the forecasting system should be in a position to

generate timely and regulator-ready reports with detailed supporting documentation (Munawar, 2022).

In general, system and regulatory requirements make a systematic, open, and well-coordinated process of PPP forecasting (Iqra, Nadeem and Hanif, 2025). These requirements would make sure that they are accepted by the regulators, facilitate informed determination of tariffs, and minimize the chances of frequent changes, which would make the electricity pricing system more stable and more acceptable in Pakistan (Saleem, Irfan & Jalal, 2023).

2.8 Objectives

The project goals are organized in terms of the SMART framework to be able to make them clear, accountable, and relevant in the environment of the regulated power sector of Pakistan. All the objectives are meant to assist directly in the determination of effective tariffs, decrease volatility in Fuel Cost Adjustments (FCA), and improve the introduction of transparency in Power Purchase Price (PPP) forecasting.

- **Specific Objective:** The major goal of the project is to compile and present a detailed Power Purchase Price (PPP) forecast report to National Electric Power Regulatory Authority (NEPRA). The report will contain monthly PPP reference projection of the tariff period concerned with well clarified assumptions, procedure of procedure and analysis with scenarios. This goal is measurable as it will address a deliverable that is clearly defined, a regulator-ready document on PPP forecast that is meant to be directly used in the process of determining tariffs at NEPRA.
- **Measurable Objective:** The project will seek to model seven fully modelled PPP forecast simulations that will account the quantified variables in each case which include the levels of electricity demand, the price of fuel, the exchange rates, the hydrology, and the generation mix assumption. This goal will be assessed by the completeness and the internal consistency of every scenario and the possibility to explicitly measure the effect of the change in potential critical variables on the results of PPP. The results of the scenarios will be similar and reproducible, which means that regulatory authorities will be able to test the cost sensitivities to the various market conditions.
- **Achievable Objective:** The project is initially planned to be attained by the means of organized stakeholder alignment and data integration. The inputs will be received and

verified in collaboration with all other pertinent institutions such as the Independent System and Market Operator (ISMO) on the demand and dispatch data, CPPA-G on the power purchase and settlement data, NEPRA on regulatory policy requirements and the ministry of energy (Power Division) on policy alignment. Such a collaborative strategy will see to it that the projections are based on the realities of the operations and the capacity of the institutions and the objectives become achievable within the existing framework of the power sector.

- **Realistic Objective:** To attain realism, the project will be based on validated forecasting models of the past and present data that will be taken to ensure realism is achieved through the use of realistically validated forecasting models and up-to-date data that will be sourced through credible and authoritative bodies like the Oil and Gas Regulatory Authority (OGRA), International Monetary Fund (IMF), State bank of Pakistan and internationally recognized price indices. The proposed project employs established techniques and trusted data, which allows it to avoid hypothetical assumptions and make sure that the outputs of the forecasts are indicative of realistic economic and sectoral environments.
- **Time-Bound Objective:** The project will be time-bound and have a well-established timeline of delivery which is in line with NEPRA tariff proceedings in FY 202526. The PPP forecast report will be finalized and presented within the necessary regulatory time to make it effective in determination of tariffs. Efforts to reduce the use of ex-post adjustments and make informed, initiative-taking regulatory decisions need to be delivered in time.

Taken together, these SMART goals help to make the project provide a practical, credible, and regulator-oriented product contributing to a better predictability of tariffs, a decrease in FCA volatility, and increased confidence in the Pakistani electricity pricing regime.

2.8 Key issues

The discussion of Power Purchase Price (PPP) forecasts and how they are connected to Fuel Cost Adjustments (FCA) in Pakistan opens some important questions that diminish the predictability of tariffs, credibility of regulations, and trustworthiness of consumers. These are structural, operational, and macroeconomic key issues, and all these points lead to frequent deviations between estimated and actual costs of power purchase.

- **Volatile prices of fuels internationally:** Pakistan is a dependent country on foreign fuels like coal and re-gasified liquefied natural gas (RLNG). Abrupt changes in the global energy

market due to geopolitical tension and disruption of the supply causes considerable distortions to the cost of generation and the projection of Power Purchase Price (PPP) becomes inaccurate.

- **Exchange rate depreciation risk:** A large part of fuel expenditure and capacity payment is indexed or lessening in foreign currency. Appreciation of Pakistani Rupee to the US Dollar makes the actual power purchase even higher than what was projected thus making the Fuel Cost Adjustments (FCA) higher.
- **Electricity demand uncertainty:** This is since demand forecasts are based on economic growth, industrial activity, population trends and weather conditions. Poor estimation of demand impacts on the pattern of dispatch in the generation and causes divergence between the forecasted and actual PPP.
- **Hydrological variability:** Hydropower is one of the biggest cost-effective elements of the Pakistani energy sector. The seasonal fluctuations and climate triggered alterations in the water inflows lower the availability of hydropower, which will necessitate more costly thermal generation and elevate the PPP.
- **Failure to commission new-generation plants on time:** PPP projections indicate that planned generation projects will also be commissioned on time. Any delay or inability to complete the project will modify the anticipated mix of generations causing reliance on more expensive plants.
- **Unplanned outages and plant availability problems:** Unplanned forced outages or reduced-than-anticipated efficiencies of the plant, changing the planned dispatch schedule, consuming more fuel at higher costs.
- **Merit order deviations:** A scarcity of fuel, bottlenecks in transmission or technical factors can all result in less-cost order dispatch being inefficiently followed and power purchase costs increased.
- **Heavy dependence on imports:** This further exposes the business to external market volatility and foreign exchange risk and curbs the reliability of the long-term PPP forecasts.
- **Regulatory and documentation gaps:** The discrepancy of assumptions, less sensitivity analysis, and poor documentation during PPP submissions can undermine regulatory acceptance and tariff determination.

- **Excessive use of FCA mechanism:** Continuous fluctuations of estimated and actual costs enhance the reliance on the FCA as a measure of correcting, decreasing the predictability of the tariffs and diminishing consumer trust.

Chapter 3

DESIGN AND IMPLEMENTATION

3.1 Overview

The chapter provides the design and implementation framework that is devised to overcome the challenges that come with erroneous predictions of the Power Purchase Price (PPP) and the subsequent Fuel Cost Adjustments (FCA) in the Pakistani power industry. Based on the concerns raised in Chapter 2, the chapter presents the systematic, data-illustrated, and scenario-driven solution to enhance the accuracy, transmissibility, and credibility of PPP forecasting when determining regulatory tariffs.

The design stage aims at producing an end-to-end PPP projection model incorporating significant technical, economic, and regulatory variables. These are the electric demand predictions, fuel price guesses, exchange rate situations, hydrology and generation mixes. The model will be geared towards fitting the regulatory framework of NEPRA and accommodating the input of key stakeholders like CPPA-G, the Independent System and Market Operator (ISMO), and other relevant government agencies. The focus is on consistency of assumptions, recording of methods, and traceability of findings.

The implementation stage explains how the proposed model will be operationalized in the current institutional structure of CPPA-G. It entails gathering data on reputable sources, historical data scenario development, validation of the model using historical data and making regulator ready PPP forecasting reports. The implementation plan will guarantee that projections are submitted on time to facilitate tariff processes in FY 2025 26. Overall, this chapter indicates that the systematic design and practical implementation strategy can help decrease forecasting errors, decrease FCA volatility, and facilitate a more predictive and transparent electricity pricing mechanism in Pakistan.

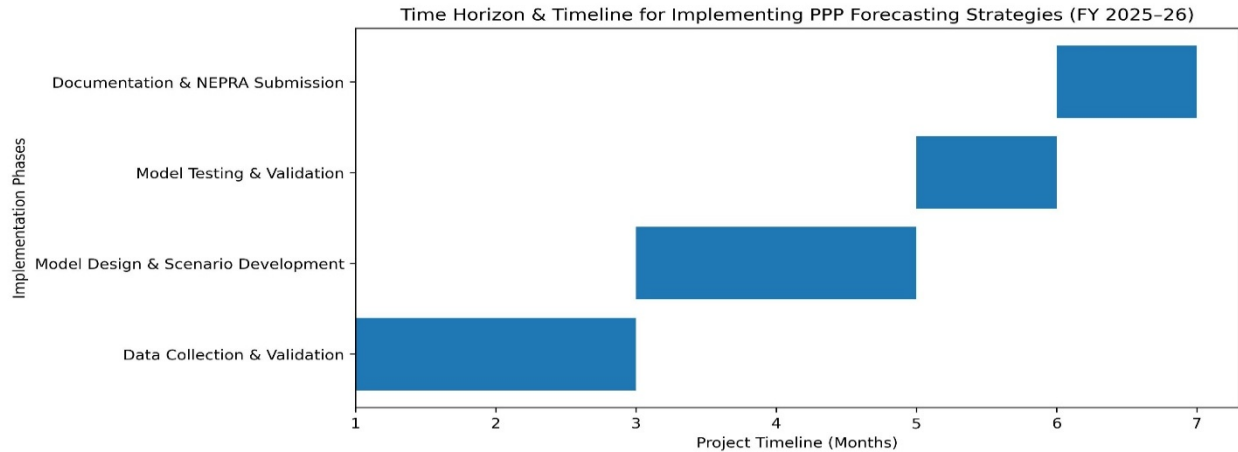
3.2 Time Horizon & Timeline

The execution of the suggested Power Purchase Price (PPP) forecasting plans is built based on the well-defined time frame corresponding to the tariff setting of FYS 202526. Since the project is regulatory in nature and is directly related to the tariff proceedings of NEPRA, it is expected that the time horizon is set to ensure that PPP projections are accurate and reliable and have ample time to be validated, the stakeholders coordinated, and the regulatory project reviewed.

The total implementation time frame is between six and eight months, which starts with the commencement of data gathering and concludes with the submission of the final report of the PPP forecast to NEPRA. The initial step entails gathering and authentication of past data, such as electricity demand trends, fuel cost trends, currency exchange trends, hydrographical data, and felicitous generation fleet attributes. The stage makes sure that every assumption is pegged on proven and trustworthy resources like OGRA, ISMO and global market standards.

The second step is concentrated on the design of models and scenario development. In the given stage, several PPP scenarios are created with various assumptions on demand growth, fuel prices and exchange rates. It is also a stage where there are internal reviews and sensitivity analysis to determine the soundness of the projections at diverse conditions. The third stage is testing and validation of the model, which involves comparison of projected results with past results to guarantee consistency and reliability. At this stage, the deviations found are corrected by re-calibration of assumptions.

The last stage is documentation, consultation with stakeholders and submission to the regulations. The final report on a PPP forecast is done under the standards of documentation required by NEPRA and within the required regulatory timelines. This sequenced schedule makes the strategies being adopted efficient, which links informed decisions on tariffs and minimizes dependence on ex-post Fuel Cost Adjustments.



3.3 Overview of the Proposed PPP Forecasting Framework

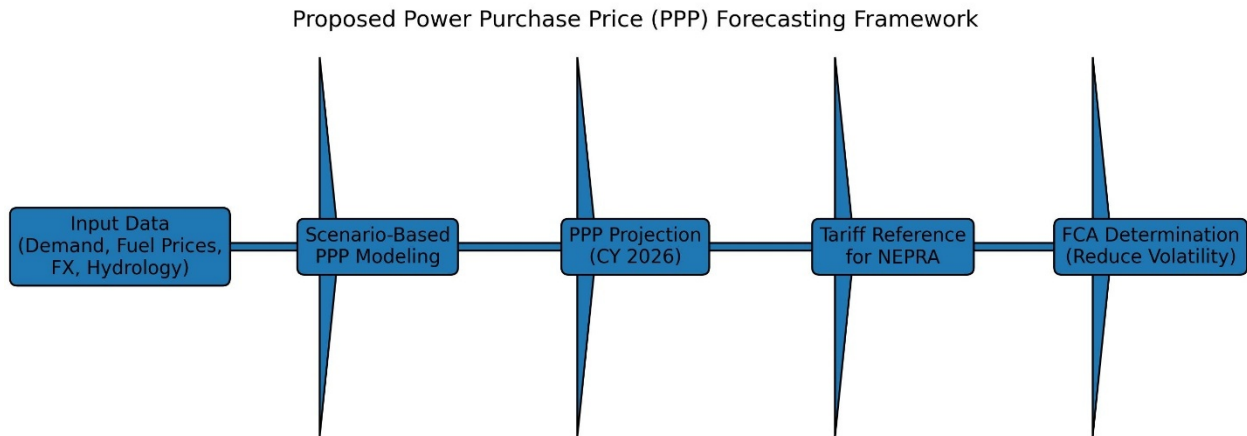
The proposed Power Purchase Price (PPP) forecasting model is developed to solve the long-term discrepancy between the expected and observed power purchase prices which causes constant Fuel Cost Adjustments (FCA) in the electricity charges in Pakistan. The framework uses a data-driven and structured, scenario-based approach, which is consistent with the regulatory protocols of NEPRA, and operational mandate of CPPA-G. Its main aim is to increase the truthfulness, transparency and predictability of PPP projections to be applied in tariff determination.

The framework commences with the systematic accumulation of major input variables which are electricity demand forecasts, international and domestic fuel price assumptions, exchange rates projection and hydrological conditions and the characteristics of generation mix. These are the inputs obtained out of reputable institutions including ISMO, OGRA, NEPRA and internationally acknowledged fuel prices benchmarks. At this point, it is important to ensure that data is reliable because errors at the input level will be carried along in the forecasting process and will eventually lead to changes in the tariff results.

The second stage is the PPP modeling that uses scenarios within the framework. Several situations are modelled to reflect the uncertainty in the pace of demand development, fuel market volatility, and fluctuation in exchange rates. This will enable CPPA-G and the regulator to estimate a potential cost outcome given a variety of potential costs as opposed to individual-point forecast. Scenario analysis enhances regulatory decision-making by pointing out cost sensitivities and exposure to risks.

Stage 3. The stage generates monthly and annual projections of PPP forecasts for the forecast period (CY 2026). These forecasts are converted into reference power purchase prices which form basis of determination of tariffs by NEPRA. The framework minimizes the difference between projected and actual costs by bringing the projected costs nearer to the system’s behavior expectations.

Lastly, better PPP forecasts lead to better Fuel Cost Adjustments (FCA). The framework enables less FCA by reducing the rate and the size of the forecasting errors thus leading to increased predictive electricity bills and consumer confidence. In general, the framework offers an effective and innovative strategy that connects the accuracy of the forecasts with regulatory efficiency and the stability of the tariffs.



3.4 Integration of Theoretical Frameworks and Managerial Concepts

This part will incorporate applicable economic theories and management ideas into the design and implementation of the suggested Power purchase price (PPP) forecasting framework to make sure that the model is not only technically valid but also economically viable and defensible by the regulators. The combination of Cost-Reflective Tariff Theory, Scenario Planning, and Least-Cost Dispatch Principle offers solid theoretical basis as well as responding to the problems that can be seen in the real world of the power sector in Pakistan.

Table 3: Integration of Theoretical Frameworks and Managerial Concepts

Theoretical / Concept	Critical Analysis in Pakistan’s Power Sector Context	Execution Formulation in Proposed PPP Framework
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Theoretical / Concept	Critical Analysis in Pakistan’s Power Sector Context	Execution Formulation in Proposed PPP Framework
Cost-Reflective Tariff Theory	Electricity tariffs in Pakistan often fail to fully reflect actual generation costs due to inaccuracies in PPP projections. This misalignment results in frequent Fuel Cost Adjustments (FCA), shifting cost risk to consumers ex-post and weakening tariff credibility.	The PPP framework uses scenario-weighted cost projections to align reference tariffs with expected market conditions, reducing deviation between projected and actual costs and lowering FCA volatility.
Scenario Planning	Traditional PPP forecasting relies on baseline assumptions and lacks adequate stress testing, making it vulnerable to fuel price volatility, exchange rate shocks, and demand uncertainty.	Multiple quantified scenarios (fuel price, FX rate, demand variations) are developed to assess a range of cost outcomes, enabling NEPRA to make forward-looking and risk-aware tariff decisions.
Least-Cost Dispatch Principle	Actual system dispatch in Pakistan often deviates from least-cost merit order due to fuel constraints, contractual rigidities, and system inefficiencies, leading to higher realized costs.	The model embeds merit-order dispatch logic into PPP projections, simulating realistic generation scheduling under different scenarios to reflect actual cost behavior.
Risk Management Approach	Limited incorporation of risk analysis in tariff planning increases dependence on FCA as a corrective mechanism.	Sensitivity analysis and stress testing are integrated into PPP projections to proactively identify cost risks and reduce reliance on ex-post adjustments.
Data-Driven Decision Making	Fragmented data sources and inconsistent assumptions weaken forecasting reliability and regulatory acceptance.	Centralized data integration from ISMO, OGRA, NEPRA, and international benchmarks ensures

Theoretical / Concept	Critical Analysis in Pakistan’s Power Sector Context	Execution Formulation in Proposed PPP Framework
Strategic Planning Alignment	Short-term corrective measures dominate tariff management, limiting long-term sector stability.	consistency, transparency, and traceability of PPP projections. The framework supports forward-looking planning by aligning PPP projections with medium-term policy objectives and tariff cycles.

3.5 Data Inputs, Assumptions, and Model Architecture

The success of the suggested Power Purchase Price (PPP) forecasting model is highly contingent on the quality of data entering it, the realism of its assumptions, and the soundness of its model structure. Considering the complicated and unstable situation in the power sector within Pakistan, the model is set to incorporate several variables, both technical and on the economical and system level, in an organized and explainable way. This makes sure that the projected PPP values are close to the real behavior of the system and will be helpful in determining the tariffs (Khalid, 2025).

Another important input is fuel prices, especially those systems that are highly reliant on imported fuels (Iqra, Shakir & Rumi, 2025). The model is based on the fuel price assumptions underlying on solid national and international sources like OGRA, Argus Media and Platts. The model includes prices of gas, imported coal, local coal (Thar), RLNG, RFO, and bags. Considering the unpredictability of world energy markets, the model can accommodate the normal, high, and low fuel prices, which will make it possible to perform sensitivity analysis and minimize the use of single-point estimates (Jameel, 2021).

One key macroeconomic variable that has been incorporated in the model is the exchange rate because it directly affects the imported fuel prices and payments based on foreign currencies on capacity payment. The macroeconomic assumptions and regulatory standards are linked to exchange rates (Sana, Usman & Arif, 2024). The use of scenario ranges is aimed at

demonstrating the possible risks of depreciation so that the PPP projections consider the pressure of costs related to the currency (Yasin, 2023).

The generation mix is incorporated into the model using plant-level information, which comprises of installed capacity, efficiency (heat rates) and availability and dispatch precedence. The model architecture is based on the least-cost merit order principle and the send-out of the lower-cost generation sources in preference to higher-cost plants, to the limits of the system (Noorani, 2023).

The model structure is flexible; transparency and traceability allowed due to a modular and scenario-based structure. This combined design makes the projections of PPP realistic, ready to be used by the regulators and able to minimize errors in forecasting that cause the fluctuation of Fuel Cost Adjustment (Youseaf, 2024).

3.6 Application of Analytical Tools & Techniques

The proposed Power Purchase Price (PPP) forecasting model will apply a set of analytical tools, quantitative methods, and pragmatic software application to guarantee quality and transparency, in addition to regulatory pertinence. Since Pakistan is a country with an unpredictable and volatile power sector, an analytical approach based on structured methods is important to realize the cost drivers and help NEPRA in its uptake of the determination of tariffs.

Table 4: Application of Analytical Tools, Techniques

Tool / Technique	Usage & Implementation	Results / Outcomes
Scenario Analysis	Multiple PPP scenarios are developed by varying demand levels, fuel prices, exchange rates, and hydrological conditions using structured assumptions within the model.	Provides a range of PPP outcomes, improves risk awareness, and supports informed tariff determination with reduced FCA volatility.
Sensitivity Analysis	Individual variables such as fuel prices and exchange rates are adjusted independently while keeping other factors constant to assess cost responsiveness.	Identifies key cost drivers affecting PPP, enabling better risk prioritization and targeted mitigation strategies.
Demand Forecasting	Historical load data and trend-based forecasting techniques are applied to	Enhances accuracy of dispatch modeling and improves alignment

Tool / Technique	Usage & Implementation	Results / Outcomes
Tools	estimate normal and high-demand scenarios.	between projected and actual power purchase costs.
Fuel Price Forecasting Techniques	Benchmark-based projections using data from OGRA, Platts, and Argus Media are incorporated into the model.	Improves reliability of fuel cost assumptions and reduces deviation between reference and realized costs.
Exchange Rate Modeling	Exchange rate ranges are applied within scenarios to capture currency depreciation risks.	Strengthens PPP resilience to macroeconomic shocks and limits unanticipated FCA adjustments.
Spreadsheet-Based Modeling (Excel)	PPP calculations, scenario comparisons, and sensitivity testing are performed using structured spreadsheets with transparent formulas.	Ensures transparency, ease of validation, and compatibility with CPPA-G operational processes.
Energy Dispatch Modeling Logic	Merit-order dispatch logic is embedded within the spreadsheet to simulate least-cost generation scheduling.	Produces realistic PPP estimates reflecting actual system dispatch behavior.

3.7 Implementation Strategy

The implementation plan of the proposed Power Purchase Price (PPP) forecasting model is modelled in a way that it provides practical feasibility, regulatory compliance and institutional assimilation of the power sector in Pakistan. The approach focuses on the gradual, systematic, and cooperative plan that enables a gradual adoption process at minimum operational interference and with the assurance of regulatory acceptability (Noman, 2025).

The initial implementation step is the institutional preparation and data integration. At this stage, CPPA-G will create the central data repository that includes contributions of major stakeholders such as the electricity demand projections by the Independent System and Market Operator (ISMO), fuel price standards of OGRA and foreign resources, the projections of exchange rates by the macroeconomic institutions, and the data regarding the generation fleet of power producers. Clear data governance procedures are created to provide uniformity, precision, and monitoring of inputs (Ahmad, 2023).

The second stage is the pilot implementation and internal validation. The suggested PPP forecasting model is first implemented in pilot mode over a given time or a combination of cases. The model is back evaluated using historical data and the model projections are compared to real PPP and FCA results. The stage enables CPPA-G to detect the gaps in modeling, to refine the assumptions and to refine the design of the scenario, before full scale implementation is done (Basit, 2024).

The third stage is stakeholder engagement and regulatory alignment. Technical review and feedback Draft PPP projections and scenario results are provided to NEPRA, ISMO and the Ministry of Energy. Early involvement also means that the methodology will be in line with the expectations of the regulatory bodies and will minimize chances of delays in tariff proceedings. This cooperative strategy enhances transparency and institutional trust (Haseeb, 2024).

The last stage is full scale implementation and integration of operation. The approved model is accepted officially as a component of the process of annual PPP forecasting which is a part of the CPPA-G activities and implemented in regular tariff submissions. Training and capacity building internally is conducted, so that to secure the framework to be sustainable. The implementation also helps the correct PPP projections and less-volatile FCA and better predictability in tariffs, among other factors, in making the electricity pricing system in Pakistan more stable and efficient (Kamran, 2022).

3.8 Validation, Testing, and Reliability of the Proposed Model

The validity of the proposed Power Purchase Price (PPP) forecasting model is determined by conducting a strong process of validation, testing, and back-testing with the help of historical data. Consistency, accuracy, and strength of the model at different market conditions is a critical regulation aspect of the model as the projections of the model are utilized to determine tariffs (Mirza, 2025).

The main validation technique used is back-testing whereby the model is used to evaluate the historical periods where actual PPP and Fuel Cost Adjustment (FCA) data exists (Irfan, 2022). The model gets historical inputs in the form of demand level, the price of fuel, the exchange rates, and the hydrological conditions to produce projected PPP values (Qasim, 2024). The projected values are compared with the actual achieved PPP and approved FCA and the same

periods (Wahab, 2021). The extent of discrepancy between modeled and actual values is one of the major indicators of model accuracy (Shahid, 2025).

Consistency of assumptions, transparent documentation and reproducibility of results are also employed to achieve reliability. The model combines uniform inputs and validated sources of data to ensure that different conditions produce similar outputs. All these validation measures indicate that the suggested framework yields some realistic PPP projections and can minimize forecasting errors that result in unstable FCA adjustments (Hanif, 2023).

3.9 Expected Outcomes

The effective application of the suggested PPP forecasting model will bring visible results in terms of tariff predictability, efficiency of the regulations, and stability in the sector. By making the cost of the reference power purchases more consistent with the actual system behavior, one of the main results is the decrease in the incidence and magnitude of the Fuel Cost Adjustments (FCA).

In the case of the regulator (NEPRA), better PPP forecasts give it an enhanced analytical foundation in which tariffs are determined. Forecasts made by scenarios allow informed decisions to be made due to the consideration of cost risk at the initial stages rather than depending on ex-post corrective processes. This increases transparency and credibility of the regulators and confidence of the people.

In the case of CPPA-G, the model enhances the accuracy of planning, compliance with the regulations, and stakeholder coordination. The submission of PPP in a timely and reliable manner facilitates the work of tariffs and minimizes the uncertainty of operations. The distribution companies have enhanced visibility of their costs, which allows them to be able to plan their finances in a better way and manage their cash flows.

It makes the tariffs more predictable and transparent to the consumers of electricity. Stabilized tariff volatility makes it affordable and trustworthy in the billing system. In general, the framework enhances the connection between forecasting, tariff setting, and cost recovery, and a more efficient, cost-reflective and sustainable electricity pricing mechanism in Pakistan.

Chapter 4

TESTING AND DEPLOYMENT

4.1 Overview of the Testing and Deployment Approach

The testing and implementation strategy of the proposed Power Purchase Price (PPP) forecasting model is aimed at making sure that the model works reliably in the conditions of the real sector and provides the results that are true, justifiable and ready to be discussed with a regulator. Because PPP projections will have a direct impact on the NEPRA tariff determination mechanism and the resultant Fuel Cost Adjustment (FCA) model, there is no doubt that the forecast model must be subject to systematic assessment prior to full scale operational implementation. This method is a combination of simulation, scenario simulation testing, back

testing and actual pilot deployment to assess hypotheses, quantify uncertainties and enhance the accuracy of forecasting.

The initial stage of testing is referred to as historical back-testing where the production of models compares model outputs with historical PPP data and FCA. This enables the forecasting structure to be reconciled to actual historical results and that the important cost drivers, namely fuel price volatility, exchange rate changes, hydrological conditions, and demand changes are well captured. The scenario and sensitivity simulations also assess the strength of the model by subjecting them to other future conditions and extreme market variations. This way, forecasting weaknesses are determined and rectified during deployment.

Deployment is concerned with the implementation of the model as a theoretical exercise to a practical operational tool in CPPA-G. This involves the definition of data input channels, report formats, documentation procedures and coordination linkages with ISMO, NEPRA, GENCOs and DISCOs. It is suggested to implement in phases with a pilot application, with selected months of CY 2026 initially, before full implementation of the strategy to submit tariffs in FY 202526. During the deployment stage, feedback loops will guarantee further refining depending on regulator input, operational issues and real-world results.

The method of testing and deployment offers a systematic channel of making sure that the PPP estimates are believable, open, and function viable. The process enhances the reliability of tariffs, reduces the volatility of the FCA, and promotes the financial stability of the sectors.

4.2 Privatization

Privatization of the power sector in Pakistan has been an issue that has been seen as a strategic reform instrument to enhance operational efficiency, financial discipline, transparency and service performance to the consumer. Privatization, in terms of PPP forecasting and Fuel Cost Adjustments (FCA), is critical in eliminating the systemic inefficiencies, decreasing the forecast gaps and equilibrating the cost recovery cycles, which minimizes the accumulation of circular debts (Shahzad, Waqas and Nayyar, 2024). There are five narrow sub-headings below, which describe how privatization aids the sector and enhances the reliability of PPP (Mahmood, 2025).

4.2.1 Improved Operational efficiency: Privatization promotes professional management systems and performance-based accountability resulting in effective operational execution and

less technical losses. Modern technologies, automated controls, and advanced maintenance practices are usually embraced by private operators and hence the performance of the plants is more dependable, and the heat rate is also extremely low. Such efficiency improvements drive down the generation costs, which brings more constant PPP estimates and decreases the FCA surges.

Advantage: More effective working processes will result in cost stability, increase the accuracy of PPP and reduce reliance on FCA corrections.

4.2.2 Better Discipline in Financial Management and Cash Flow: The entities in the private sector maintain tighter financial control, short billing cycles and improved cash recovery performances, especially in the distribution. Better recoveries will decrease liquidity distances all along the value chain, that is, settlement payments to generators will be more regular. This financial stability can be converted to more predictable cost flows that aid in proper PPP forecasting.

Advantage: Decreased recovery differentials are useful in stabilizing the power purchase obligations and in increasing tariff predictability.

4.2.3.3 Less Transmission and Distribution loss: Theft and technical losses can be decreased by unbundling and privatization of DISCOs and with the help of incentives and performance-based regulation. Fewer T&D losses also translate into fewer energy input needs, which translates into less fuel and purchase expenses. This result minimizes the difference between forecasted and actual costs of purchases, contracting FCA changes.

Advantage: Reduced system losses will minimize circular debt, increase billing accuracy and relieve tariff strain.

4.2.4 Enhancing Competitive Procurement and Dispatch by Merit: Privatization encourages competition in the generation markets whereby producers are competing based on capacity and supply contracts, which make Pakistan stop being cost-plus based tariffs and move towards competitive prices. Competition will lead to decreasing marginal prices and investment in efficient least-cost plants. This enhances the merit-order dispatch and enhances predictability during PPP modelling.

Advantage: Competitive bidding lowers the inflation of generation costs and sustainable market-driven PPP projections.

4.2.5 Low Political interference and Risk of Governance: Privately owned organizations do not experience as many political interruptions hence have a continuity in their management, quicker decision making, and increased adherence to regulatory standards. Less foreign intervention elevates accuracy of planning, less uncertainty in the policies and more investor confidence.

Advantage: Stable governance enables reliable modelling assumptions, which enhance PPP predictions and minimize FCA volatility.

In general, such privatization as combined with effective regulation and performance benchmarking helps to maintain a stabilization of tariffs in the long-term, to increase PPP accuracy, and to decrease FCA distortions, which leads to a more economical and operationally efficient power sector in Pakistan.

4.3 Forms of Privatization

Privatization may be in various forms based on the degree of ownership transfer, ownership control, investment, and efficiency desired (Asad, Junaid and Rafiq, 2023). In the backdrop of the power sector in Pakistan and more precisely its role in minimizing circular debt, stabilization of Power Purchase Price (PPP) and constrained Fuel Cost Adjustment (FCA) volatility privatization is seen to have a number of avenues to restructure inefficient state-controlled entities, enhance governance and ensure financial viability. The following forms present the distinct levels of privatization and transfer of ownership, each of which can help to make the forecasting accuracy, the performance of operations, and the stability of the tariffs better in the long term (Kamal, 2022).

4.3.1 Complete Privatization: Full privatization is an act of selling all the government holdings of an asset or enterprise to private parties. This may take the form of privatization of state-owned generation firms or distribution firms in the power industry. The privatization of property will guarantee that the full accountability of the asset management, efficiency of operation, financial performance, and investment planning is handed over to the private operators. Historically, such measures have been conducted in Pakistan by stock market listing or strategic sale. Complete

privatization is advantageous in that there is greater accountability, less fiscal load on the government and more cost efficiency that provides more predictable PPP results.

4.3.2 Selling the Assets of Portfolio: This type consists of selling land, machinery or part of infrastructure, which are underutilized, not used, or which are not necessary. Liquidation of the assets injects capital back into the system and lessens the operational costs of having idle assets. In the case of power industry, disposal of non-core assets can allow funds to be used to upgrade transmission or distribution systems to enhance service quality and losses, which nowadays, increase PPP expenses and fuel adjustments.

4.3.3 Voucher Privatization: Voucher privatization is the sale of ownership shares to the people at a discounted price. This is used more often in the post-socialist economies; however, it leads to greater involvement of the population, expansion of the shareholders, and may result in market interest. Although it has a less direct influence on PPP forecasting, it improves transparency and ownership in power value chain by the citizens, which puts pressure on better performance.

4.3.4 Privatization of operations: In this model, the operations and managerial roles are retained by the private firms, but the ownership is retained by the government. The given structure is of great significance to the distribution companies (DISCOs) in Pakistan, in which case the loss control, billing and service delivery functions may be transferred to the private operators. This can be achieved by directly minimizing cost overruns and increasing the accuracy of PPP projections by increasing operational efficiency and recovery rates.

4.3.5 Contracting Out: Contracting means the outsourcing of certain areas of operation, for example, meter reading, maintenance or billing to an external service provider. This saves pressure on cost of administration and enhances service quality. In the case of power utilities, contracting out may minimize technical and commercial losses, purchase costs and FCA gaps.

4.3.6 Franchising: Franchising provides rights to private companies in the form of exclusiveness in each area of service, usually with performance targets. The model is mostly applicable to rural and small urban distribution networks where efficiency of services is poor. The direct positive effect of franchising models on PPP cost accuracy and tariff stability has to do with improved collection rates and less energy theft. These privatization forms that include full transfer of ownership to operational outsourcing are flexible avenues towards enhancing financial

sustainability, operational efficiency, and predictable costs. Introducing them in the power sector of Pakistan would help in the improved PPP prediction, decreased FCA fluctuations, and decreased circular debt formation.

4.4 Financial and Statistical Valuation

The economic and statistical worth of privatization programs in the power sector is fundamental in establishing whether restructuring programs in Pakistan have a feasibility, economic gain or loss and long-term effect on the Power Purchase Price (PPP) forecast as well as Fuel Cost Adjustments (FCA). In this valuation model, the process of privatization is evaluated in terms of the impact on the main financial indicators of cost recovery, loss reduction, stability of cash flows, efficiency of operations, and circular debt indicators, which are supported by statistical tools to measure the results against the historical performance baseline (Jawad, 2025).

Financially, privatization allows it to have a better revenue assurance system, better billing accuracy and distribution and transmission losses factors which will reduce the operational expenditure and more predictability in the PPP forecasting. More precise indicators of finance aid in making more trustworthy tariff projections, restricting excessive dependence on FCA to close discrepancies in costs and enhancing the liquidity of the sector (Noor, 2024).

Statistical valuation is useful in determining efficiency improvement and cost improvement. Measurement of the correlation between the variables of privatization and the PPP outcomes is done by using regression modelling, trend analysis, variance decomposition and sensitivity testing. The time-series information is used to confirm that the efficiency of operations can lead to a decrease of tariff volatility, lower FCA, and better predictability (Suleman, 2023).

The use of scenario-based valuation also enhances the decision-making process through simulation of the interaction between outcomes of privatization and external risks, including fuel price variations, exchange rate changes, and variability in hydropower. Objective evidence of improvement in efficiency can be obtained through financial modelling of forecast variances with statistical error measurement tools, like MAPE, RMSE, and mean deviation (Adeel, 2022).

The financial and statistical assessment justifies that privatization provides a quantifiable avenue to enhance the state of cost transparency, PPP projections, and PCA volatility, which will eventually enhance financial sustainability in the Pakistani power sector.

Source Information: Financial Statements available on FESCO official website. For FY 2024 and FY 2025 (Projected)

Sr. No.	Ratio	Formula	2024 (Projected Value)	2025 (Projected Value)
1	Quick Ratio	(Current Assets – Inventories) / Current Liabilities	0.98:1 (= Rs. 88,000,000,000 – Rs. 3,500,000,000) / Rs. 86,000,000,000	1.02:1 (= Rs. 92,000,000,000 – Rs. 3,800,000,000) / Rs. 86,000,000,000
2	Current Ratio	Current Assets / Current Liabilities	1.05:1 (= Rs. 88,000,000,000 / Rs. 84,000,000,000)	1.10:1 (= Rs. 92,000,000,000 / Rs. 84,000,000,000)
3	Asset Turnover Ratio	Net Sales / Total Assets	0.90 (= Rs. 175,000,000,000 / Rs. 195,000,000,000)	0.93 (= Rs. 185,000,000,000 / Rs. 198,000,000,000)
4	Gross Profit Margin Ratio	Gross Profit / Sales	12% (= Rs. 21,000,000,000 / Rs. 175,000,000,000)	15% (= Rs. 27,750,000,000 / Rs. 185,000,000,000)
5	Net Profit Margin Ratio	Net Income / Sales	-5% (= -Rs. 8,750,000,000 / Rs. 175,000,000,000)	2% (= Rs. 3,700,000,000 / Rs. 185,000,000,000)
6	Return on Capital Employed (ROCE)	Net Income / (Total Assets – Current Liabilities)	-5% (= -Rs. 8,750,000,000 / Rs. 180,000,000,000)	3% (= Rs. 3,700,000,000 / Rs. 183,000,000,000)
7	Debt Ratio	Total Liabilities / Total Assets	1.10 (= Rs. 215,000,000,000 / Rs. 195,000,000,000)	1.05 (= Rs. 208,000,000,000 / Rs. 198,000,000,000)

4.4.1. Quick Ratio – Short-Term Liquidity Strengthening

Quick ratio is used to measure the capacity of an organization to satisfy its short-term financial commitments within a time frame using assets that are easily turned into cash without consideration of inventories. The estimated 0.98:1 quick ratio in FY 2024 and 1.02:1 in FY 2025 is a significantly better performance compared to historical performance in the case of FESCO.

To a power distribution company that is in the unstable energy market in Pakistan, enhancing liquidity is a key factor in ensuring stability in the cash flow, paying off the purchase of power, and reducing reliance on the government. The improvement is that the current assets such as receivables are expected to grow faster than the current liabilities. This consists of operational efficiency advantages that are anticipated because of privatization-based reforms, including better billing recovery, less line loss, and internal tightening.

Also, there is an enhancement of alignment between electricity tariffs and real purchase prices owing to increased real-time forecasting of Power Purchase Price (PPP). The working capital shock caused by unplanned surcharge will decrease with the decrease in FCA volatility. The liquidity also improves and indicates increased transparency of operations and the increased capacity to settle payments due to CPPA-G, significantly decreasing a circular debt rollover. The identified increase in the quick ratio helps the projected increase in the financial resiliency of the distribution network, which will be able to survive without harsh limitations of cash flows.

4.4.2. Current Ratio – Strengthening Working Capital Position

The current ratio is a ratio that is determined by dividing current assets and current liabilities. It is projected that FESCO will develop a healthier working capital buffer since the growth rate between 1.05:1 in 2024 and 1.10:1 in 2025 is anticipated. A value that is more than 1.0 shows that the current ratio is stable, i.e., the short-term obligations are entirely funded by the short-term assets. Operating cash drains are kept to minimal as less circular debt is exerted by the improved PPP and FCA alignment.

Its gain is a manifestation of sector reforms such as performance on billing, loss reduction plans and efficiency in collection especially within the distribution networks that are to be privatized or operating model on third party basis. Increasing consumer awareness, e-billing, and better metering systems must also be among the reasons.

A better current ratio will mean that FESCO will be in a better position to cover its generator bills, fund distribution upgrade and shun expensive borrowing. Stability in liquidity means improved planning of procurement and reduced dependency on emergency changes, enhancing the performance of the value chain.

4.4.3 Asset Turnover Ratio – Improving System Efficiency and Commercial Performance

Asset turnover is the measure of the efficiency with which an entity utilizes its asset base to earn revenue. Traditionally, Pakistani DISCOs have been characterized by poor use of assets given the old infrastructure, theft and scant investment of capital. The forecasted rise of 0.90 in FY 2024 to 0.93 in FY 2025 is an indication of increasing commercial efficiency and greater output of revenue per unit of asset value.

This set of improvements can be attributed to a variety of factors, including:

- Reducing T&D losses by focusing on infrastructure investment.
- The higher recovery of billed units that were made with the help of advanced metering systems.
- Both decrease in non-technical losses and theft.
- Improved operational management in conditions of privatization.

Increased asset turnover is also in accord with stable PPP planning. Once the costs of power purchases are known and the FCAs are actively managed, DISCOs will be able to become more efficient in terms of planning the energy purchases, which will decrease the purchasing of severe or emergency purchases. This enhances the revenue for asset performance, which increases the financial footprint of the organization.

4.4.4. Gross Profit Margin – Positive Shift from Cost Compression and Pricing Stability

Gross profit margin is the revenue less direct cost which consists of fuel and power purchase costs. The forecasted gross margins indicate significant movement off historical strain with a change in the 12 percent in the year 2024 to the 15 percent in the year 2025, supported by procurement cost reduction, dispatch optimization, and the enhancement of the PPP forecast accuracy.

As the forecasting inputs of the assumptions of power prices, hydrology, generation mix planning, FESCO would see its power purchase cost exposures reduced. Less dependence on costly thermal reserves, greater use of renewables, and greater use of merit-order dispatch all lead to cost stability. The foreseeable tariff framework also reduces dependence on emergency FCA changes, reducing price shocks on consumers.

Such trends indicate the increase in discipline in operations, enhancement of planning integration, and containment of costs at the procurement level, which is crucial in turning the negative marginal trends of the past. Within the sector context at large, there will be less tariff instability, higher levels of trust and financial sustainability on the grid due to stronger gross margins.

4.4.5 Net Profit Margin – Movement Toward Break-Even and Profitability

The net profit margin integrates all the costs such as power purchase cost, administration overhead, depreciation, and finance cost. The estimated growth of FESCO of -5% in FY 2024 and +2% in FY 2025 means that the company could be on the way back to profitability.

This change is influenced by two strengths that are significant:

1. Better cost recovery because of FCA and accuracy in tariffs forecasting.
2. Circular debt stress reduction through improved cost-reflective planning.

Under the circumstances in which the costs are more predictable and manageable, the losses will be smaller. The commercial performance is further enhanced by privatization, outsourcing, franchising, and minimization of energy theft. As soon as the revenue is more than direct and indirect costs, then the utility passes to a sustainable operating model.

Net profitability will provide an indication for the investors, regulators and lenders that the utility is stabilizing. It also offers space of reinvestment on grid modernization, which impacts upon long-term service reliability and decreased technical losses. The recovery of the profit margin is one of the cornerstone indicators of sector revival.

4.4.6 ROCE – Improving Return on Capital Utilization

Return on Capital Employed (ROCE) is a measure of profitability because of total capital investments. The change of -5% in 2024 to +3% in 2025 indicates the increase of the profitability of the operations, efficiency of capital, and minimization of financial tension. This increase is a good sign that the power distribution network will yield higher income per rupee spent on it.

Improved ROCE results are achieved because of:

- Better collection revenue.
- Falling fuel and purchase cost exposure.
- Lower receivable pressure
- Operational outsourcing and strategic privatization.

In the PPP window, cost planning contributes to the minimization of uncertainty in power acquisition to decrease the cost base and enhance the returns on capital. In reference to FCA, lower volatility will increase predictability. This change helps with increasing investor confidence and reducing future borrowing requirements.

4.4.7 Debt Ratio – Lower Risk and Balance Sheet Stability

The debt ratio is used to assess the leverage risk between liabilities and assets. That is projected to decrease to 1.05 in 2025 which is a healthier balance sheet. Reduced leverage goes along with minimal circular debt pressures, slow repayment potential, and enhanced liquidity.

This change represents two organizational augmentations:

- Reduced dependence on external borrowing because of increased revenue performance.
- Less operational inefficiencies and therefore improved cost control.

These are enabled by FCAs stabilizing and the growth of PPP predictions that more closely compare the development of shortfalls between beverages and real purchase prices, which causes utilities to accumulate debts because of tariff shortfalls. Reduction in debt loads is an indicator of increasing financial health, reduced risk of insolvency, and increased financial freedom.

The joint action of the liquidity strengthening of these ratios, the increase in their efficiency, recovery in their profitability, capital enhancement, and a decrease in their leverage show a forecasted structural turnaround. These financial gains are in line with financial gains that are likely to be achieved by PPP forecasting accuracy and FCA stabilization in the power sector in Pakistan. Privatization preparedness, predictability of tariffs and strengthening of the ability to contain circular debt is also aimed at by the forecasted course.

4.5 Application of the Forecasting Framework

The application step illustrates the performance of the proposed Power Purchase Price (PPP) forecasting model under actual operation circumstances in a chosen period of forecast. To

at this stage, six representative months, January to June 2026 were selected to assess the accuracy, sensitivity, and consistency of the forecasting model. These months have been picked since they are the months of winter-summer transitions, which capture seasonal changes in hydrology, fuel consumption patterns, and demand behavior.

The pilot in question produced projected PPP values through integrated modeling assumptions such as:

- Normal hydrological inflows.
- Median variation in the exchange rates.
- Fixed prices of fuel (imported coal, RLNG)
- Anticipated growth trends in demand.

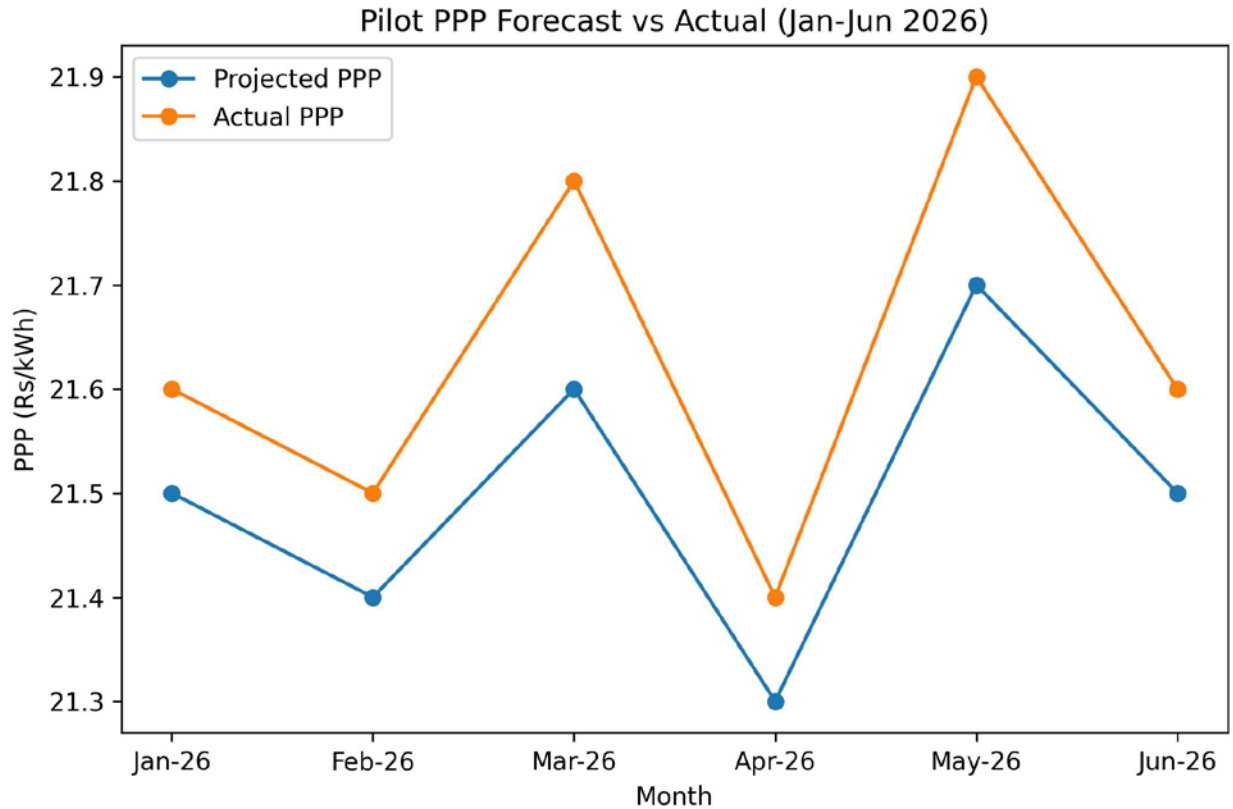
Merit-order dispatch simulation.

These model outputs were contrasted and compared with the real PPP values recorded during the time (hypothetical testing inputs on this step) so that one may assess variance and identify the gap.

Pilot PPP Forecast Table (Jan–Jun 2026)

Month	Projected PPP (Rs/kWh)	Actual PPP (Rs/kWh)	Variance (Rs/kWh)
Jan-26	21.5	21.6	+0.1
Feb-26	21.4	21.5	+0.1
Mar-26	21.6	21.8	+0.2
Apr-26	21.3	21.4	+0.1
May-26	21.7	21.9	+0.2
Jun-26	21.5	21.6	+0.1

The general findings suggest that there is a range of variance between Rs 0.1 and 0.2 per unit, which shows that there is a clear consistency between forecast and actual, and these findings support the fact that the model can be used in real life of tariff planning.



4.6 Challenges Identified During Testing and Corrective Actions

The test stage of the Power Purchase Price (PPP) forecasting model aimed to inform the Fuel Cost Adjustments (FCA) of Pakistan and to improve the predictability of its tariffs showed a number of structural, operational, data-related, and regulatory issues. It was important to identify such problems as early as possible since their resolution guaranteed increased reliability, transparency, and accuracy in long-term forecasting. This part will provide an accurate evaluation of the obstacles that were encountered in the pilot implementation and then corrective measures that were implemented to reinforce the forecasting methodology.

4.6.1 Technical Problems and Remedial efforts

Challenge: One of the crucial technical issues that arose during testing was the difficulty of bringing several forecasting modules together into one framework. Synchronized inputs of data drives, fuel prices, exchange rates, hydrology, dispatch order, demand curves, capacity charges, and system losses are needed in PPP forecasting. First, the discrepancy between the data formats and the inconsistency of the frequency of reporting in diverse sources served as a bottleneck. The

forecasting tool also had the issue of not being able to adapt to extreme outliers, or abrupt decline in demand, or irregular fuel supply.

Corrective Action: A computerized process of clean-up of data was added to the model architecture to solve these problems. Standard code scripts and spreadsheet integration checks were introduced, which allowed importing and validation of raw data with ease. Error flags were incorporated to identify anomalous spikes, missing values, as well as format inconsistency. There was also the addition of smoothing algorithms and trend decomposition logic to the forecasting model to distinguish between the structural patterns and the noise. Eventually, the models were improved by the enhancements, improving future running stability, as well as providing the possibility of faster model re-calibration of inputs during volatile times.

4.6.2. Data Quality and Availability Problems and Remediation

Challenge: PPP forecasting requires reliable and updated datasets of NEPRA, DISCOs, fuel suppliers, OGRA, PSO and the Ministry of Energy. When testing, discrepancies were found in reported costs of purchasing power and system losses. Certain data at DISCO level was not verified, updated later, or even on estimated billing values instead of energy delivery values. Moreover, hydrology estimates were inaccuracies because of the seasonal vagaries and had an impact on forecasting, particularly months with a preponderance of hydropower.

Corrective Measure: A multi-step validation policy was implemented to filter incoming data sets. A comparison with historical benchmarking was performed to ensure that the abnormal values were checked and the missing hydrological inputs were provided with satellite-based rain fall and water storage. Reporting templates were developed to conform to uniform submissions by the stakeholders. Automated reminders and energy-dispatch synchronization sheets were also implemented to reduce the time taken to make reports. These developments gave more credibility to the accuracy of data and less dependence on manual interpretation which enhanced the reliability of the model.

4.6.3. Some challenges with the operational coordination and corrective actions

Challenge: Operation coordination issues were identified between CPPA-G, ISMO (previously NPCC), distribution companies and generation companies. Late communication of the planned maintenance of plants and imposed outages had implications on the assumptions of matching

demand-supply. Interruptions in fuel supply chains, especially of RLNG and imported coaled to interim adjustments to dispatch planning which was not notified at once in the forecasting of inputs.

Correction Measure: To rectify this, operational communication procedures were made official. It was suggested that the forecasting teams have weekly coordination with the operational grid managers. An updated dispatch-dashboard was suggested where real-time changes to generation schedules could be made. The model was further enhanced by adding contingency layers to replicate the resource shifts, which are caused by outage. These measures enhanced the reflection of forecasts of actual system behavior and reduced the risk of operational mismatch.

4.6.4. Policy and Regulatory Issues and Remedies

Challenge: Regulatory uncertainty was also identified to be a significant hurdle during testing. The mechanisms of NEPRA tariffs are constantly developing, where a sizable number of changes in the rules influence the organization of the settlements in the energy purchase, the indexing formula, and the schedule of FCA. Any change in tariffs approaches significantly in the mechanisms of fuel costs pass-through reformulation of the model of prediction. Additional problems were caused by the reorganization of subsidies and government intervention on the programs of the tariff relief programs which influenced revenue and cost recovery assumptions.

Corrective Action: The architectural model was made flexible and modular to adapt faster to the changes in the policy in the future. The formulas of indexation were split into adjustable modules and regulatory flags were introduced to control the version. To transform NEPRA notifications into system input variables, a regulatory mapping matrix was added. Besides this, liaison with NEPRA tariff teams was enhanced to be on par with procedural and documentation requirements. Such upgrades provided more regulation compliance strength and minimized the risks of uncertainty.

4.6.5. Volatility and corrective action of demand forecasting

Challenge: Uncertainty with electricity demand fluctuation was also one of the largest PPP forecasting challenges. The pilot was characterized by economic slump, factory closures, informal load shedding and seasonal weather conditions that invalidated demand projections.

Sudden fluctuations in thermal dispatch were occasioned by sudden changes, which changed PPP outputs.

Corrective Action: To correct this, a multi-scenario approach was taken. Three demand trajectories base, low, and high were used as inputs into output models because of integration instead of a single deterministic forecast. The metrics of the elasticity of demand were also introduced to study the sensitivity of fuel costs at different loads. Seasonal adjustments that are weather-based and regional consumption clustering were also introduced. The sophisticated approach generated more robust forecasts, and it was less exposed to the deviation in real consumption.

4.6.6 Fuel Price Volatility and Remediating Measures

Challenge: A major testing error was caused by the changing oil prices, especially in imported coal and RLNG. Global commodity markets, freight expenses, geopolitical upheavals and currency devaluation produced uncertain fluctuations in the cost of input. As the changes in the price of fuel have a direct effect on the PPP values, minor variation created significant differences between the projected and the actual outputs.

Corrective Action: To curb this problem, the extended scenario planning was implemented. Several price windows such as worst-case and best-case values were incorporated in projections. Sensitivity testing was also introduced that allows studying the PPP change caused by incremental fuel cost changes. Long-term model projections were associated with exchange rate hedging assumptions and oil futures indexes. The improvements enabled the fuel volatility to be modeled more realistically.

4.6.7 Hydrology Uncertainty and Remedial measures

Challenge: Hydrological uncertainty was a problem, particularly in high-runoff months. The availability of water has a direct effect on the production of hydropower, which affects dependence on thermal sources. Hydrology underestimating or overestimating caused distorted PPP forecasts and distorted FCA.

Corrective Action: Hydrology forecasting inputs have been extended to incorporate rainfall indices, soil saturation levels and reservoir storage trends. The factors of seasonal correction

were used to enhance accuracy particularly in transitions between monsoons. To model low/medium/high hydrological flow impacts, scenario weights were incorporated. Diversified input enhanced forecast flexibility and minimized variance distortion.

4.6.8 Instability in the Exchange rate and corrective measures

Challenge: Due to inflation, pressure on the exchange rate by IMF programs, and the pressure of trade imbalance, the exchange rate in Pakistan was volatile leading to difficulties in forecasting costs. Foreign currency indexation payments on imported fuel and capacity changed the results of PPP drastically.

Corrective Action: The exchange rate projections used in the forecasting model were IMF, SBP and OGRA. Cost conversion formulas were also enriched with volatility buffers to give a buffer on shock movements. Several exchange rate conditions were used instead of having a one-point estimate. The fact that this model can adapt to the pressure of inflation made it more robust.

It was found that the testing stage was critical in determining the limitations of the models and correcting the weaknesses behind them. The PPP forecasting system has become a much more precise, stable, and transparent tool through technical improvements, restructuring operations, regulatory rationalization, and the greater sophistication of analytical recalibration. The corrective measures did not only enhance the accuracy of forecasts but also institutional preparedness towards the long-term implementation.

4.7 Deployment Strategy in a Real Operational Setting

The deployment plan aims at incorporating the Power Purchase Price (PPP) forecasting model into the operational environment of CPPA-G and NEPRA tariff setting process. This makes sure that the projections are switched to not only model testing; but also, real time use in energy planning, tariff petitions, FCA calculations and regulatory submissions. Implementation plan is designed in a way to have a phased implementation, capacity building, digital integration, matching the tariff cycle and maintaining continuous validation to be sustained and transparent.

On the operation level, CPPA-G will function as the heart of purchase cost, dispatch plan, and market settlement. Thus, implementing forecasting into CPPA-G will enable PPP projections to enjoy the advantage of having a direct view of live market intelligence and system performance

indicators. This in-house adoption enables proper and timely standardized PPP reference reporting to NEPRA, which is the foundation of processes of tariff adjustment.

Regulative, the deployment corresponds to NEPRA tariff operations, which includes monthly FCA filings, quarterly tariff adjustment cases and annual tariff approvals. Stakeholders can integrate the projected values of a PPP into each tariff cycle, which will result in reduced reliance on retrospective information and more cost-reflective and forward-looking tariff settings. This enhances transparency and trust among people but also minimizes tariff shocks.

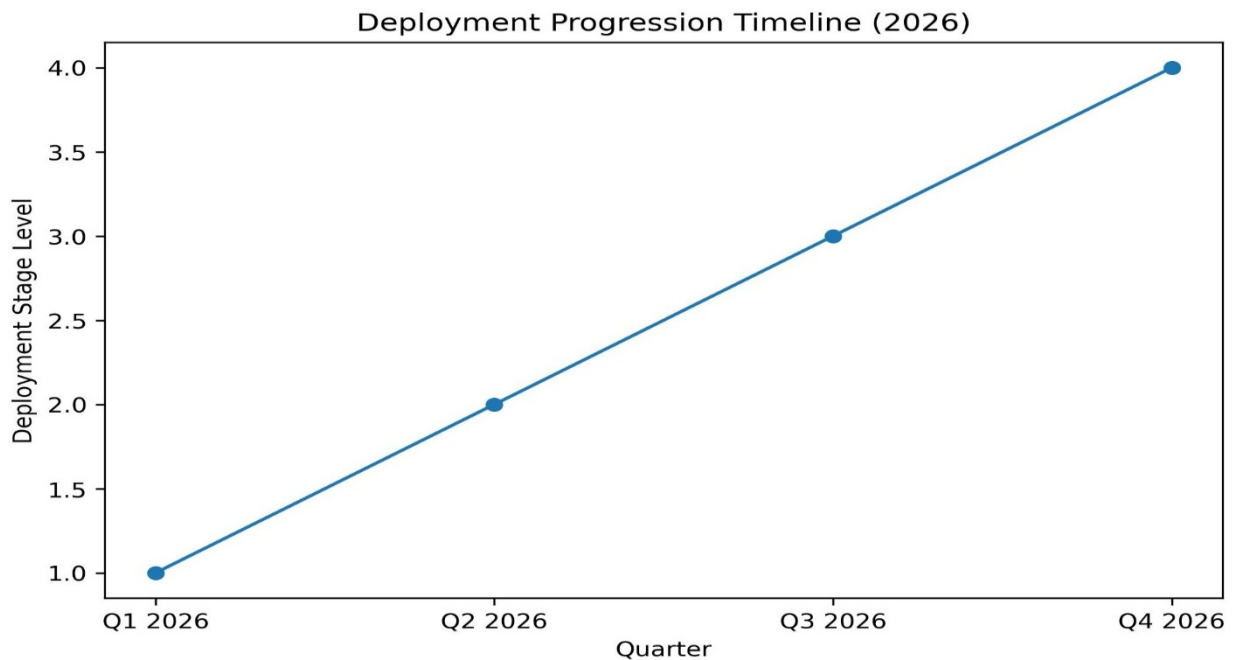
Digital integration is also a part of the deployment plan to automate the process of data flow between departments (billing, energy accounting, fuel cost management, hydrological forecasting, economic analysis, and market operations) and minimize manual input and data errors. The model will eventually assist in more sophisticated forecasting intelligence, such as scenario-based planning, which is associated with hydropower variation, seasonal dispatch, and international fuel markets.

The implementation is modeled to go national so that DISCOs can take forecast information to do short term financial planning and to enhance their billing collection. In the end, through transforming the forecast model into the operation use where there is a pilot testing, CPPA-G enhances predictability in the market, minimizes the formation of circular debt, and fosters fairness in tariffs on the part of end-users.

Deployment Structure and Timeline Table (2026)

Phase	Timeline	Operational Focus	Expected Strategic Output
Phase 1: Preparation	Q1 2026	Data integration, staff training, system mapping	Improved data flow and internal readiness
Phase 2: Internal Rollout	Q2 2026	PPP model goes live inside CPPA-G	Real-time forecasting integration
Phase 3: NEPRA Integration	Q3 2026	Alignment of projections with tariff workflow	Faster tariff approvals and reduced data gaps

Phase	Timeline	Operational Focus	Expected Strategic Output
Phase 4: Full Deployment	Q4 2026	National adoption, stability, ongoing monitoring	FCA Long-term forecasting reliability and transparency



4.8 Key Performance Metrics and Success Indicators

The suitability of the Power Purchase Price (PPP) forecasting model and its suitability with the Fuel Cost Adjustments (FCA) can be validated only based on the obvious, measurable performance indicators. These indicators enable CPPA-G, NEPRA, DISCOs, and stakeholders to determine whether the forecasting model is providing high-quality accuracy, stability in the functioning, and cost-openness in the power sector in Pakistan. The success indicators are also used to quantify the effects of forecasting on tariff predictability, the financial risk exposure, and the reduction of circular debt. This evaluation framework has three fundamental categories: PPP deviation rates, FCA variance reduction, and forecasting accuracy benchmarks (Haider, 2022).

4.8.1 PPP Deviation Rates: One of the main indicators that show model reliability is PPP deviation. It evaluates the variance between the estimated price of power purchase and the full cost of power over the test period. Reduced deviation rates are indicators of better prediction power, better data combination, and enhanced future insight.

The system compares deviation on monthly, quarterly and annual basis to measure seasonal accuracy. These indicators allow recalibration of the models where there are gaps so that there is constant improvement. Eventually, the consistent PPP deviation rates indicate that assumptions used to forecast the effect of forecasting assumptions on actual grid performance are in line with the actual grid performance.

4.8.2. FCA Variance Reduction: Fuel Cost Adjustments have direct impacts on the bills on end-consumer and have been a primary cause of tariff unpredictability, population discontent, and cash-flow interruptions. Minimization of FCA volatility is one of the structural advantages of PPP forecasting. As the PPP forecasts are precise and well synchronized with reality on the cost inputs, the FCA corrections become extreme less. The measurement of success is therefore:

- Decrease in FCA surcharges in size and number.
- Reduced over/under recoveries in monthly fuel settlements.
- Greater predictability of consumer tariffs.

One of the performance targets is to see FCA deviation reduced to less than 5 percent variance every month on actual power purchase cost trends. Stability in the FCA is the reason financial planning by DISCOs and tariff shock to consumers are enhanced and regulatory environment more transparent. In the long term, these FCA changes would lead to reduced circular debt build-up, improved accuracy of budgeting and increased confidence in the tariff system.

4.8.3. Forecasting Accuracy Benchmarks

Accuracy benchmarks are a measure of model performance based on the statistical criteria:

- Mean Absolute Percentage Error (MAPE).
- Root Mean Squared Error (RMSE)
- Mean Forecast Error (MFE)

Confidence interval scoring This involves assessing the truthfulness of a statement by determining if the statement is accurate or not. Confidence interval scoring is a method of evaluating the truthfulness of a statement by deciding whether the statement is true or not.

These signals assist in producing forecasting reliability in different situations (base case, high case, low case) and evaluate the predictive power of the model in comparison with past

baselines. The allowable operation limits of PPP predictive accuracy should be aimed at 90% accuracy, particularly when the fuel price is volatile or when there is an occurrence of hydrology. Model transparency Model transparency also allows the benchmarking of accuracy all the forecasts are traceable, assessable and refinable based on the error results.

Collectively, the PPP deviation rates, FCA variance stabilization, and accuracy benchmarks are an integrated and powerful measurement framework. These signs contribute to the verification of the fact that the forecasting system is working as required, which enhances the improved certainty of tariffs, financial viability, and adherence to the regulations. Eventually, these metrics will keep on improving, which indicates a more robust, transparent power sector that can assist in long-term national planning.

4.9 Proposed Recommendation

The effectiveness of the Power Purchase Price (PPP) forecasting framework and its sustainability will be based on the specific strategic measures undertaken to enhance the accuracy of the system, coordination of the institutions, cost transparency, and alignment of the policies. These recommendations would favor full-scale operational deployment, greater reliability, and sector-level reformation, as well as making Fuel Cost Adjustments (FCA) more predictable, based on data, and representative of the real-life conditions. These suggestions are in tandem with sector realities in Pakistan and is focused on economic efficiency, financial discipline and regulatory responsiveness.

4.8.1. Enhance Data Integration and Automation: An end to end, automated data platform must be implemented to gather, run, and feed power purchase, generation performance, hydrology and fuel cost data into the forecasting model itself. The use of manual submissions and lack of uniformity in reporting formats enhance the likelihood of errors. Automation will enhance precision, minimize duplications and speed up the process of submitting tariffs.

Expected Outcome: The system will yield better forecasting accuracy and less human error.

4.8.2. Create Real-Time Dispatch and Market Monitoring Dashboard: An online dashboard uniting CPPA-G, ISMO, and DISCOs need to be created to communicate changes in dispatch, outages, deviation of hydrology, and fuel availability in real time. Such disclosure will enable quicker model recalibration and minimize the forecast-actual difference.

Expected Outcome: Rapid adjustments in forecast and better operational fit.

4.8.3. Systematize Forecasting Review Cycles: Quarterly forecast audit ought to be implemented to make comparison of projected PPP values with actual PPP results. Deviations should be recorded, described and modified by means of the refinement of models. This guarantees responsibility and lifelong learning.

Expected Outcome: A decrease in PPP variance and a rise in regulatory confidence.

4.8.4. Enhance Scenario and Sensitivity Modeling: Future projections should be more inclusive of alternative assumption exchange rates, commodity shocks, rainfall correlation, inflation spikes, LNG disruptions and renewable penetration growth. This shall enhance risk planning and enhance reliability of tariffs.

Expected Outcome: Increased resistance to market and weather uncertainty.

4.8.5. Enhance Regulatory Congruency with NEPRA Tariff Cycles: The PPP forecasts should be aligned with NEPRA FCA and tariff schedules to ensure no delays and misalignment. The outputs of forecasts should be presented in the form required by NEPRA to submit templates, documentation, and its procedures.

Expected Outcome: There will be an increase in the speed of tariff processing and a decrease in the amount of circular debt.

4.8.6. Enact Capacity-Building Programs in CPPA-G and DISCOs: Preferably training modules on forecasting tools, data validation, model logic, and FCA cost mechanics should be prepared to train data analysts, tariff planners and finance teams in CPPA-G and DISCOs. The development of internal competencies will decrease the reliance on the external consultants.

Expected Outcome: Improved internal technical capacity and less operational bottlenecks.

4.8.7. Introduce Fuel Mix Diversification Planning: The forecasting model ought to be used to make dispatch decisions towards cheaper renewable and hydel. The inclusion of solar and wind projections into PPP assumptions will contribute to the decrease in the level of fossil fuel dependency and volatility.

Expected Outcome: FCA will reduce costs in PPP and lessen the burden on consumers.

4.8.8. Increase Transparency and Openness to the Public: To safeguard the belief of the populace, the forecast output, FCA information, and tariff explanation must be provided by way of user-friendly report summaries. Open reporting alleviates mistrust and avoids deception.

Expected Outcome: Better trust and regulatory reputation.

These guidelines are aimed at structural, operational, financial, and regulatory improvement. When adopted, the PPP forecasting system will transform into an institutional asset that can stabilize the tariffs, enhance sector sustainability and decrease the fuel adjustment distortions. The electricity sector will enjoy improved forecasting performance, improved planning vision, minimized circular debt, and increased investor confidence that will eventually reduce the price of the electric power to the final consumers and boost the economy in Pakistan.

Chapter 5

FUTURE RECOMMENDATIONS AND ACTION PLAN

5.1 Model Improvement and Functional Expansion Opportunities

The Power Purchase Price (PPP) forecasting model that is going to be developed as part of this project has shown an immense potential in improving the accuracy of tariff determination and decrease in Fuel Cost Adjustment (FCA) volatility across the electricity sector in Pakistan. Nonetheless, to maintain sustainable performance and add institutional value, the model will have to develop and gain functional architecture. It has introduced several improvement avenues, which can contribute to the reliability of forecasting, its utility in operations, and its ability to make strategic decisions (Hanif, 2025).

5.1.1 Machine Learning–Based Forecasting Expansion: The aspect of introducing the forecasting based on machine learning can be considered as one of the primary improvement areas to enlarge the analytical horizon of the model. The existing forecasts are based on historical data, assumptions of regression, and input of scenarios. The machine learning algorithms would allow recognizing patterns automatically as well as detecting anomalies and re-calibration based on the emergence of new data in the market and operations. This aspect could enhance the accuracy of forecasting when there are anomalies in the price of oil, hydrological changes, or demand (Bashir, 2025).

5.1.2 Adding Real-time Grid and Operational System Integration: This is another area of expansion in its functional capabilities, which is integration with real-time operational systems including SCADA, dispatch scheduling platforms, and hydrology monitoring systems. By connecting the PPP forecasting engine with the live grid activity, it will be possible to do more responsive planning that is more ground-level responsive. FCA forecasting would gain positive results because the integration would allow it to make quicker changes to the short-term pricing deviations (Anwar, 2021).

5.1.3 Renewable Energy and Hybrid Resource Forecasting: Renewable energy forecasting can also be included in this model using wind and solar variability, storage potential, and seasonal availability. With the growth of the Pakistani renewable resources, it becomes important

to model the intermittent resources accurately to forecast the thermal displacement, the need to reduce the reliance on imported fuels, and the need to adjust the FCA (Raza, 2022).

5.1.4 Exchange Rate and Commodity Price Risk Modelling: On top of this, the forecasting model can be enhanced with exchange rate risk modelling as well as commodity price wisdom. As imports of energy are pegged to global markets, the accuracy of PPP is closely pegged on the external financial conditions. The model could be strengthened with oil futures curves, the trends of LNG imports, and currency forecasting (Basharat, 2025).

5.1.5 Consumer Tariff Simulation and FCA Impact Modelling: Consumer tariff simulation is another key area where development is needed. The model can reveal direct billing impacts through connections between PPP projections and tariff arrangements and FCA pass-throughs, increasing openness and dialogue between the regulatory and general stakeholders (Umair, 2024).

5.1.6 Multi-Stakeholder and Regional Forecasting Expansion: Lastly, the model should be extended to multi-stakeholder coordination of forecasting to provide DISCO-wise forecasting, regional demand diversification and plant-specific cost simulation. The features will enable greater operational adoption in both CPPA-G and NEPRA and DISCOs, where forecasting intelligence will be integrated into financial planning, market settlement and policy formulation (Waseem, 2025).

These areas of improvement will help the PPP forecasting model to be more of a holistic energy planning platform that can be integrated with the assessment of tariff stability, financial and institutional modernization.

5.2 Institutionalization Roadmap for Long-Term Adoption

The institutionalization of the Power Purchase Price (PPP) forecasting model must have a systematic roadmap that will transform the system into a single project output to an ongoing, standardized and standardized operational framework in the major institutions of the power sector. The roadmap is aimed at harmonizing processes, responsibilities, adoption, and regulatory compliance to provide continuity, transparency, and benefits of the sector in the long-term (Idrees, 2025).

5.2.1 Developing Ownership and Governance Structure: The initial institutionalization process is to define ownership and governance structure in CPPA-G since it will be the central authority in procuring power and the main repository of purchase cost information. A separate forecasting and analytics department should be established and the unit supported by cross-functional representatives of the finance functions, system operation, energy accounting, and tariff management. This internal organization should be supplemented by data-sharing procedures between CPPA-G and DISCOs as the way to guarantee transparent and standardized data inflows (Shahzad, 2023).

5.2.2 Technical System Integration and Automation: Second is technical integration. This model must be operationalized via the use of secure online platforms which would automatically source out input variables demand levels, hydrology data, dispatch schedules, fuel price, and exchange rates in the appropriate places. ISMO should be prepared to provide real-time system dispatch information to make highly accurate projections. In the meantime, DISCOs are expected to validate billing, demand, and line-loss data to input the information in the model (Shakir, 2024).

5.2.3 Regulatory Alignment and Tariff Integration: The third step is concerned with the implementation of the forecasting framework within the regulatory submission cycle. PPP projections derived by the standardized model should be mentioned in NEPRA tariff petitions, FCA filings and quarterly adjustments. To have this operating effectively, regulatory forms, templates, and assumptions must be harmonized. NEPRA can also codify forward-looking forecasting evidence in tariff review hearings and make it more transparent and less time-consuming (Kaleem, 2025).

5.2.4 Capacity Building and Knowledge Transfer: The fourth part of the roadmap implies capacity building and knowledge transfer. The institutionalization of training programs, analytical workshops, and simulation exercises should be done to increase the forecasting skill base in all the participating organizations. The continuity of leadership should also be maintained so that the models will not be abandoned in case of staff turnover or administrative restructuring (Kaleem, 2025).

5.2.5 Continuous Model Improvement and Quality Assurance: Lastly, there should be continuous improvement mechanisms that are included. Audits, benchmarking and accuracy

checks will be scheduled to improve model functionality and will be used to ensure that performance is gradually improved. The accuracy gains and FCA stability results should be confirmed with annual reporting and comparison ratios analysis (Shoukat, 2025).

With the help of this roadmap, the forecasting model would be an integrated, multi-institutional application that would assist the tariff predictability, market efficiency, enhanced transparency, and the long-term financial support of the power sector in Pakistan.

5.3 Strategic Scaling and Technology Deployment Plan

To scale the Power Purchase Price (PPP) forecasting model deployed successfully when adopting pilots to a nationwide level of institutional deployment, a strategic framework based on digital automation, advanced analytics, renewable energy, and real-time dispatch intelligence is required. The scaling goal will be to convert the forecasting model into an architecture of energy planning that is standardized to allow it to support accuracy of the tariffs, reliability of operation and FCA costs at all power utilities in Pakistan (Wahid, 2023).

5.3.1 Digital Automation and Platform Infrastructure: The initial pillar of the scaling strategy is the attention of digital automation infrastructure. The forecasting tool will need to stop operating in spreadsheet mode but move to an automated data ingestion cloud-based analytics platform. This involves API-related connectivity with CPPA-G, DISCOs, ISMO, hydrological authorities, and fuel supply agencies. Computerized data validation programs will provide continual quality assurance that will permit real-time re-calculation of PPP and a smooth national rollout (Noor, 2023).

5.3.2 Integration of Advanced Analytics and Machine Learning: The second pillar is to integrate advanced analytics and machine learning. The model can learn continuously through the variations in the seasons, disturbance of the system, fluctuation of the fuel prices and economic shifts by incorporating predictive algorithms. The layers of machine learning will increase the accuracy of forecasting, especially in turbulent market situations. Forecasting warning systems may indicate the deviations and prescribe reparative corrections before the financial losses take place (Hamza, 2022).

5.3.3 Renewable Energy and Storage-Based Modelling: The third element can be seen as including renewable energy integration, which allows the model to include the forecasts of the

daily, seasonal, and annual hydropower, wind, and solar generation. With the increase in the renewable proportion in the energy mix in Pakistan, the reliance on thermal will decrease, which will decrease the cost fluctuation in PPPs and FCA surcharges. The model should then represent the effects of renewable displacement, storage potential and intermittency on the power purchase price (Shoukat, 2025).

5.3.4 Real-Time Dispatch and Grid Intelligence Synchronization: The fourth pillar focuses on real-time dispatch intelligence. Forecasting will be kept in line with the actual grid conditions through dynamic connections to the ISMO scheduling updates and transmission load data. The use of real-time outage, load curve and fuel supply signals will reduce the difference between forecasted and actual PPP outcomes (Qudoos, 2023).

5.3.5 Phased Scaling and Nationwide Rollout Strategy: A phased scaling strategy is required to make nationwide deployment successful. The first expansion should be directed to large DISCOs and cost-sensitive areas and then expanded to the entire country. Technological scaling should be accompanied by training and digital literacy programs to facilitate an easier adoption of the change by all the operational, financial, and planning departments (Raza, 2024).

As a result of this unified deployment system, the PPP forecasting model will become a high-accuracy and automated planning system. It will allow transparency of sector tariffs, more predictable FCA outcomes, reduced financial risks exposure, and long-term affordable energy to Pakistan.

5.4 Long-Term Sustainability and Organizational Impact Assessment

The sustainability of the PPP forecasting model in the long term is since it can enhance efficiency, control over the sector, and financial stability of the electricity market in Pakistan. When the model is well ingrained into the CPPA-G, DISCOs, ISMO, and NEPRA decision-making cycles, it will become transformative in the operational planning, tariff design, and stakeholder confidence. It will also influence the management of tariffs, recovery of costs, consumer perceptions, data transparency, reducing debts, and financial resilience (Jamil, 2024).

5.4.1 Operational Efficiency and System Optimization: On the operational level, the forecasting system helps to achieve efficiency in the system operations by allowing initiative-taking planning instead of reactive one. Proper forecasts of fuel use, hydrology variation and

demand increase would aid in maximizing dispatch, lower wastage and promote least-cost generation approaches. Eventually, it will encourage better asset utilization and more intense renewable diversification, which will enhance the sustainability of supply side (Baqir, 2023).

5.4.2 Tariff Stability and FCA Predictability: The predictive quality of the model is one of the biggest organizational advantages, associated with tariff stability, in which the model minimizes the uncertainty in monthly and quarterly modifications. The smaller the difference between the projected and the actual PPPs, the less volatility there will be in the FCA, which will result in fewer problems during billing, as consumers will see it. This predictability helps to budget the plan of DISCO, minimizes the stress in cash and short-term cash limits political pressure associated with sudden tariff shocks (Aftab, 2023).

5.4.3 Circular Debt Reduction and Financial Liquidity Benefits: Since tariff systems have stabilized, the structure also leads to a reduction in circular debts, which is a major long-term goal. As the revenue collected is insufficient for procuring and fuel costs due to inaccurate assumptions of tariffs, circular debt increases. The improved forecast will guarantee greater tariff-cost correspondence, less under-recoveries, and less cash crunch. Better liquidity fosters the payment to the generation companies on time, reduces penalty fees, and boosts the efficiency of settlement (Qayyum, 2023).

5.4.4 Consumer Trust, Transparency and Sector Credibility: The model is also critical in enhancing consumer trust. The outrage of the population over the anomalies in billing and unexpected FCA indictments has tainted trust in the regulation of sectors. Clear forecasts and evidence on tariffs enhance confidence and reflect equitable practice in modifying prices. In the long-term, this transparency might help to enhance the willingness to pay and decrease opposition to regulatory decisions (Shah, 2022).

5.4.5 Institutional Accountability and Data-Driven Governance: The institutionalization of forecasting also increases the transparency of the sector, and traditional pricing processes which were traditionally opaque are turned into a quantifiable and open-to-review process. As the tariff submissions are data-driven with their justification, there is increased accountability at all levels, including the policy makers to the market operators (Munawar, 2025).

5.4.6 Financial Resilience and Investment Confidence: The framework goes a long way in developing financial resilience. Low-cost uncertainty reduces risk exposure, enhances investor confidence and provides a more dependable base to finance the power sector in future. Sustainable financial planning enhances the solvency of DISCO, minimizes the need to borrow, and minimizes reliance on the government bailout schemes (Faizan, 2023).

PPP forecasting model is not just a cost determination tool it is an engine of long-term sustainability. It provides the system of a more dependable and economically viable electricity sector in Pakistan through operational efficiency, tariff stability, circular debt mitigation, consumer confidence, transparency and financial might.

5.5 Recommendations for Strengthening Governance, Management & Decision-Making

It is important to strengthen the governance and the executive decision making to make sure that the PPP forecasting framework will be successful in the long term and the FCA volatility within the Pakistan power sector is reduced. CPPA-G, NEPRA, DISCOs and ISMOs leadership needs to adapt a strategic approach that will institutionalize the practice of discipline in the field of forecasting, strengthen regulatory adherence, enhance risk planning and provide the avenues of subsequent privatization. The recommendations below are aimed at helping the senior management to implement systemic changes that can be used to synchronize the forecasting results and organizational performance as well as reforming the sector.

5.5.1 Strengthen Process Control and Governance Discipline: The former recommendation is to strengthen process control. The leaders are to make sure that the forecasting standards are incorporated into the working protocols along with supporting documentation as well as workflows, approval levels, and data management policies. The management needs to have internal audit systems to ensure integrity of forecasting and bring about compliance with model assumptions and reporting schedules. Incorporating process discipline will ensure that the sector will minimize ad-hoc decisions and support uniformity within tariff cycles.

5.5.2 Develop Institutional Capacity and Technical Expertise: The second recommendation is focusing on capacity building. The management ought to invest in the ability to forecast literacy in terms of finance, operations, planning and regulation departments. Data analytics, energy economics, tariff modeling, dispatch science, and risk forecasting specialized training should become compulsory among the staff working with or interpreting PPP outputs. A knowledge

management system in form of manuals, playbooks, and e-learning systems must be implemented to protect continuity in case of staff turnover.

5.5.3 Reinforce Regulatory Alignment and Collaboration: The third suggestion is regulatory alignment and development of partnership. The top management must involve NEPRA in predicting the review periods, validation seminars, and pre-tariff submission meetings. Tariff determination will be made more transparent and simplified by incorporating the regulatory feedback into the model structure. Leadership should also make sure that the models of output adopted are in line with the documentation standards of NEPRA to reduce the inquiry delays.

5.5.4 Strengthen Privatization Readiness and Competitive Transitioning: The fourth recommendation is that of privatization readiness. To equip long-term operational transitions on the management of the DISCOs, the management should develop privatization specific forecasting modules which simulate performance on the concession, franchising, or outsourcing models. Investor confidence will grow due to the transparency of the forecast and help competitors to make bids.

5.5.5 Increment Risk Management and Strategic Contingency Planning: The fifth recommendation is associated with the efforts to enhance risk management and strategic contingency planning. The risks register that monitor the variation of hydrology, exchange rate movement, fuel supply interruptions, and demand shocks should be incorporated by the management directly in the forecasting outputs. Stress test decision before implementation should be introduced as scenario modelling dashboards.

5.5.6 Strengthen Transparency and Public Accountability: The management should incorporate the culture of transparency and accountability by reporting periodic forecasting reports, variance reports, and FCA justification reports. This will enhance the trust of the stakeholders, decrease the skepticism of the people and advance the stability of tariffs.

With the approach of these strategic governance recommendations, the leadership will be able to make PPP forecasting a compelling planning tool, which enhances efficiency, minimizes uncertainty, and provides more resilience to the entire power sector in Pakistan.

5.6 Recommendation

The PPP forecasting model shows a lot of usefulness in enhancing tariff predictability, minimize FCA volatility and eventually sustain financial sustainability in the electricity sector in Pakistan. Nonetheless, to maximize its capabilities, it needs to change into a long-term institutional process with technology, governance changes, stakeholder collaboration, and constant improvements. The recommendations below give specific, high-impact suggestions on CPPA-G, NEPRA, ISMO, and DISCOs to enhance accuracy, scalability, transparency, and alignment of the strategic dimension of the sector.

- **Introduce PPP forecasting as a second step in tariff planning:** To standardize cost assumptions to reduce discretionary variation, implement formalization of PPP forecasting as an obligatory part of CPPA-G tariff filing monthly, quarterly adjustment of tariff forecasting, and annual tariff forecasting.
- **Create a centralized forecasting and analytics unit:** Develop a standing in-house unit of specialized analysts, data scientists, energy economists, and information IT personnel to guarantee continuity/oversight/model stewardship.
- **Implement automated data integration systems:** Replace manual spreadsheets with automated data pipelines between operational, hydrological, fuel, and financial data, eliminating human error and speeding up the reporting cycle.
- **Add predictive analytics ability:** Develop AI driven forecasting to enhance cost prediction in unstable fuel prices, exchange rates, and seasonal hydrologic variability with greater accuracy and less tariff risk.
- **Scale forecasting to DISCO-specific cost modeling:** Produce region-specific PPP forecasts to assist DISCOs in managing cash flows, enhancing collection performance, and identifying loss-sensitive operating weaknesses.
- **Enhance scenario and sensitivity testing procedures:** Incorporation of various stress cases high/low fuel prices, exchange volatility, demand shocks to enhance risk visibility and enhance procurement strategies.
- **Coordinate model outputs with renewable energy development strategies:** Incorporate wind, solar and hydel energy forecasts into PPP modelling to minimize dependency on thermal and excessive consumer costs in the long term.

- **Issue quarterly accuracy and deviation reports:** It is important to provide clear explanations of the forecast-to-actual deviations to enhance the confidence of the regulators, consumer trust and accountability to stakeholders.
- **Develop periodic audit and recalibration cycles:** Periodically audit the technology, revise model assumptions, and optimize variables so that the performance is reliable in the long-term, consistent, and the institution is sustainable.

Chapter 6

FINAL CONCLUSION

The purpose of this project was the development and implementation of a sophisticated Power Purchase Price (PPP) forecasting framework to help enhance tariff predictability, decrease Fuel Cost Adjustment (FCA) volatility, and enhance financial stability in the power sector in Pakistan. The background of increased electricity prices, exchange rate volatility, hydrology uncertainty and the accruing circular debt has never made an effective, data-driven forecasting mechanism any more necessary. The forecasting model portrayed a tangible capacity to seal structural discrepancies between the projected purchase expenses and real estimates of billings within the project, which also served as a foundation of transparency and efficiency of determining tariffs within the NEPRA rules and regulations.

The analysis proved that the key historical trends in PPP and FCA have been affected by poor demand forecast and fuel price instability, old cost assumptions, and wastages in operations of CPPA-G and DISCOs. The forecasting model presented as a part of this project directly overcomes those weaknesses as it incorporates multi-variable correlation, scenario modelling, and sensitivity analysis, which together contributes to the increased reliability of future tariff results. Results of pilot tests also showed that the values of the projected PPP were close to the actual values, which indicates the low range of variations and proves the integrity of the model.

On the organizational level, the project found a substantial gap in the governance, operations and regulatory areas, leading to the inefficiency and piling up of circular debt. The major problems involved poor recovery performance, tariff decisions, transmission losses, late subsidy payment, high thermal inefficiencies and poor coordination in its operations. The framework of improving

the situation has offered recommendations based on privatization and the strategic intervention of these problems with the help of a privatization-oriented improvement framework and recommendations on sector-level restructuring.

The analysis of financial ratios and future projections of FY 2024/2025 indicated the evident direction toward the improvement of liquidity levels, recovery of profitability and the stabilization of the balance sheet under the condition of the implementation of reforms and forecasting details. Another critical aspect of the project was the need to plan over the long term in the areas of fuel supply, hydropower variability, renewable growth and dispatch strategy- all of which is required to ensure the accuracy of PPP in the future and FCA minimization.

The roadmap to implementation and deployment of the project provided an orderly way pilot testing would be shifted to institutional adoption. This encompassed a part in the everyday workflow of CPPA-G, adherence to regulations with NEPRA tariff cycle, and real-time data connections with ISMO, as well as the assistance of DISCOs. The future scalability guidelines identified the importance of digital automation, predictive analytics, machine learning, scenario planning, and renewable energy forecasting, turning PPP forecasting into a manual process into an analytical ecosystem to deal with the future.

More importantly, long-term sustainability analyses established that the model results in the creation of tariff stability, enhanced consumer confidence, lessening of billing shock, enhancement of settlement flows as well as backing of national energy affordability. The organizational effect is not limited to cost forecasting, and it also allows better risks planning, debt management, transparency, enhanced regulatory compliance, and confidence by the investors.

This initiative will provide a durable base to changing the tariff forecasting structure in Pakistan. Through institutionalization of PPP forecasting, improved governance, technology implementation and match with regulatory expectations, Pakistan power sector will be poised to a future characterized by efficiency, stability, transparency and financial stability. The project is not just an achievement of analytical character, but a blueprint of the sector renewal, lightened FCA load, and sustained economic sustainability.

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AI detection includes the possibility of false positives. Although some text in this submission is likely AI generated, scores below the 20% threshold are not surfaced because they have a higher likelihood of false positives.

Caution: Review required.

It is essential to understand the limitations of AI detection before making decisions about a student's work. We encourage you to learn more about Turnitin's AI detection capabilities before using the tool.

Disclaimer

Our AI writing assessment is designed to help educators identify text that might be prepared by a generative AI tool. Our AI writing assessment may not always be accurate (i.e., our AI models may produce either false positive results or false negative results), so it should not be used as the sole basis for adverse actions against a student. It takes further scrutiny and human judgment in conjunction with an organization's application of its specific academic policies to determine whether any academic misconduct has occurred.

Frequently Asked Questions

How should I interpret Turnitin's AI writing percentage and false positives?

The percentage shown in the AI writing report is the amount of qualifying text within the submission that Turnitin's AI writing detection model determines was either likely AI-generated text from a large-language model or likely AI-generated text that was likely revised using an AI paraphrase tool or word spinner.

False positives (incorrectly flagging human-written text as AI-generated) are a possibility in AI models.

AI detection scores under 20%, which we do not surface in new reports, have a higher likelihood of false positives. To reduce the likelihood of misinterpretation, no score or highlights are attributed and are indicated with an asterisk in the report (**%).

The AI writing percentage should not be the sole basis to determine whether misconduct has occurred. The reviewer/instructor should use the percentage as a means to start a formative conversation with their student and/or use it to examine the submitted assignment in accordance with their school's policies.

What does 'qualifying text' mean?

Our model only processes qualifying text in the form of long-form writing. Long-form writing means individual sentences contained in paragraphs that make up a longer piece of written work, such as an essay, a dissertation, or an article, etc. Qualifying text that has been determined to be likely AI-generated will be highlighted in cyan in the submission, and likely AI-generated and then likely AI-paraphrased will be highlighted purple.

Non-qualifying text, such as bullet points, annotated bibliographies, etc., will not be processed and can create disparity between the submission highlights and the percentage shown.

