Market-based Fuel Pricing Using Artificial Neural Network

Government-led Initiatives and Possible Revision

Khondaker Golam Moazzem
Helen Mashiyat Preoty
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CENTRE FOR POLICY DIALOGUE

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Executive Summary

The transition from an administered to a market-based fuel pricing system in Bangladesh, initiated in March 2024, marks a significant step towards reducing fiscal burdens and aligning domestic fuel prices with international markets. However, the existing pricing mechanisms formulated by the Bangladesh Petroleum Corporation (BPC) and the Bangladesh Energy Regulatory Commission (BERC) exhibit critical shortcomings. These include excessive multi-layered taxation, a lack of transparency, an unjustified margin structure, and an import pricing methodology that renders the economy vulnerable to external shocks. The BPC formula, in particular, imposes opaque cost layers and an inflated margin structure, contradicting global best practices in competitive energy pricing. While BERC's approach simplifies certain tax components, it remains heavily reliant on the face-value import Free on Board (FOB) price, making it highly susceptible to exchange rate volatility.

To address these deficiencies, this study proposes a pseudo-market-based pricing mechanism using an artificial neural network (ANN)-based predictive pricing model that integrates both international and domestic economic variables. Unlike the existing formulas, which primarily respond to global price fluctuations and administrative cost mark-ups, our model forecasts an effective import price of fuel oil by incorporating macroeconomic indicators such as exchange rate fluctuations, inflation, GDP growth, real interest rates, crude oil production trends, and demand-side factors. The ANN model, trained on historical data spanning over four decades, effectively captures the non-linear relationships between these variables, ensuring a more adaptive and resilient pricing strategy.

Findings from our empirical analysis indicate that current fuel oil retail prices in Bangladesh could be reduced while still maintaining a BPC margin of 3–5 per cent. For instance, the estimated effective import price of crude oil for 2024 was found to be BDT 47.60 per litre from our proposition, significantly lower than the face-value import price used in existing formulas. This results in an adjusted retail price of diesel at BDT 99 per litre, compared to BDT 130 per litre under the current pricing formula, demonstrating substantial overpricing within the existing system. The ANN model also reveals that a market-based pricing approach leads to greater price stability, mitigating economic shocks caused by abrupt and discretionary tariff adjustments. Moreover, this study also evaluates BERC's pricing formula, proposed in 2022, and finds that using the

BERC's proportional cost alongside our proposed model yields a lower per-unit fuel oil price compared to the price calculated by the BERC.

A critical policy debate emerging from this analysis concerns the trade-off between economic welfare and the green energy transition. While a market-based pricing mechanism reduces fuel costs for consumers, it also risks prolonging fossil fuel dependence by making fuel oil more affordable, thereby disincentivising investments in renewable energy. To counteract this effect, the model incorporates CO_2 emissions growth as a regulatory variable, ensuring that fuel price reductions do not lead to excessive fossil fuel consumption beyond an environmental threshold.

In conclusion, the findings underscore the necessity of reforming the fuel pricing model using advanced predictive techniques rather than relying on rigid, automatic yet administrative formulas. Additionally, to maintain the momentum of Bangladesh's energy transition, complementary carbon pricing policies, targeted renewable energy incentives, and gradual subsidy reallocation should accompany the implementation of a competitive fuel pricing regime.

Acknowledgements

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Acronyms

ACF	Autocorrelation Functions
ADF	Augmented Dickey–Fuller
AIT	Advance Income Tax
ANN	Artificial Neural Network Model
ARIMA	Autoregressive Integrated Moving Average
BBS	Bangladesh Bureau of Statistics
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
BERC	Bangladesh Energy Regulatory Commission
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
CPD	Centre for Policy Dialogue
CPI	Consumer Price Index
ECM	Error Correction Model
ERL	Eastern Refinery Limited
FDI	Foreign Direct Investment
FOB	Free on Board
FSRU	Floating Storage Regasification Unit
GDP	Gross Domestic Product
GTCL	Gas Transmission Company Limited
HSD	High Speed Deisel
IEPMP	Integrated Energy and Power Master Plan
IMF	International Monetary Fund
IPP	Independent Power Producer
JGTDSL	Jalalabad Gas Transmission and Distribution System Limited
KGDCL	Karnaphuli Gas Distribution Company Limited

KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LC	Letter of Credit
LNG	Liquefied Natural Gas
MCPP	Mujib Climate Prosperity Plan
MMCFD	Million standard cubic feet per day
NBR	National Board of Revenue
OTI	Oman Trading International
PGCL	Paschimanchal Gas Company Limited
POL	Port of Loading
RE	Renewable Energy
RPGCL	Rupantarita Prakritik Gas Company Limited
SARIMA	Seasonal Autoregressive Integrated Moving Average
TGDCL	Titas Gas Transmission and Distribution Co. Ltd.
USD	United States Dollar
VAR	Vector Autoregressive
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital

1. INTRODUCTION & OBJECTIVES

The government of Bangladesh has adopted a market-based pricing system for fuel oils particularly diesel, petroleum oil, octane, kerosene and jet fuel in March 2024. This decision has been taken to reduce the fiscal and financial burden of the government under the IMF loan condition.[1] The Bangladesh Petroleum Corporation (BPC) is the sole agency in Bangladesh for the import and supply of petroleum products throughout the country. The BPC has also been determining the petroleum price for last one decade. Previously under the regime of administered pricing system the government determined the retail price in consultation with the BPC; the pricing was driven by the international price volatility of petroleum and losses/profits of the BPC. Under the administered policy regime, the fuel price was set at a level which is not aligned with the international market price. With the fluctuation of international market prices of crude, petroleum, diesel and associated petroleum products, the BPC sometimes was in financial gains and sometimes in loss.

The adoption of periodic formula-based pricing by the BPC carries a particular significance as it needs to attain several goals. First, the goal is to reduce the fiscal burden by ending the subsidy provided to the fossil fuel-based energy system. Second, the transition from an administered pricing system to an automated pricing system will have to be in such a way that the consumers, especially vulnerable households, are not adversely affected by the revision of the tariffs. Third, the pricing mechanism needs to ensure moving towards the energy transition. Fourth, even after the adaptation, the implementation of the new pricing mechanism should also be in favour of energy security. Hence, it is essential not only to construct an appropriate pricing mechanism but also to monitor the proper implementation of the new pricing formula.

The new pricing formula adopted by the BPC is by and large short of meeting the above-mentioned goals. The new formula is being criticised for several reasons- (a) it considers an additional margin for BPC; (b) it adds a buffer price by tagging certain types of fuel oil as luxury items; (c) it adds multi-layer of tax and VATs, which has been simplified in the BERC pricing formula, cast under the NBR regulations and (d) it includes several unclear factors which need further justifications. Moreover, the BPC is functioning as both a utility importer and regulator. Unless necessary corrections are made in the official pricing formula, it will fail to meet the broader economic and social targets desired to achieve through the automated pricing formula.

In this context, it is crucial to monitor the transition from an administered pricing system to a market-based pricing system, assess the government's adapted framework, and propose necessary revisions to the pricing formula. These revisions should align with broader economic, social, and environmental objectives. Against this backdrop, the Centre for Policy Dialogue (CPD) in partnership with the Australian High Commission in Dhaka has undertaken this study.

The objective of this study is to analyse the automated pricing system adopted in Bangladesh and propose an appropriate alternative price-setting model for the fuel oil, considering both energy security and energy transition. The specific objectives of this study are:

[1]The International Monetary Fund (IMF) has decided to provide a total of USD 4.7 billion as loan mainly to ease the pressure on Bangladesh's current account balance through various reform measures. As per the timeline for implementing the related conditionality, the fuel prices were supposed to be reformed by adapting the new pricing mechanism in September 2023.

a) To review policies related with the fuel oil, particularly those related to energy pricing, and provide an overview on Australia's trade and investment interest in the renewable energy sector.
b) To highlight the key players in the energy market – such as the new Long-Term LNG SPA between Petrobangla and US-based Excelerate Energy – and assess relevant regional energy infrastructure, including India-Bangladesh Friendship Pipeline, the location of ports and regasification plants, etc. Under this objective, the study will also explore longer term trends and market opportunities;
c) To provide an overview of the subsidy regime, outlining the market structure for the different fuels. This includes assessing the total cost to government of the specific product subsidies (in terms of US dollar), total cost to consumers (e.g. in terms of inflation), and the market distortions caused by subsidies, particularly in relation to government investment in the green energy transition.
d) To review the global market-based energy pricing mechanisms and identify the suitable options that Bangladesh could consider while designing its pricing mechanism.
e) To analyse the current automated[2] pricing formula and compare it with the market-based pricing strategies with a view to identifying the required adjustments to ensure energy and socio-economic security, and its possible role in energy transition in the country;
f) To develop an alternate price-setting model and test its possible applicability in the context of the energy market of Bangladesh; and
g) To propose an appropriate price-setting model for fuel oil in Bangladesh, ensuring alignment with the current market scenario, while retaining the country's historical trend of improved market conditions.

2. REVIEW OF POLICIES, INSTITUTIONS AND SUPPLY CHAINS OF THE ENERGY MARKET OF BANGLADESH: FOCUSING ON FUEL PRICING

2.1 Review of Policies and Institutions with a Special Focus on Fuel Pricing in Bangladesh

2.1.1 Energy related policies and perspectives on energy pricing from the energy transition point of view

The issue of energy pricing is not reflected properly in most of the energy and power related policies of Bangladesh. Major energy and power-related policies include the ongoing 8th Five Year Plan (FYP), Integrated Energy and Power Master Plan (IEPMP), Mujib Climate Prosperity Plan (MCPP), Perspective Plan, National Energy Policy and Renewable Energy Policy. The energy pricing mechanism is marginally reflected in the national policies/plans in Bangladesh. The 8th FYP emphasised on the justified and proper pricing of the energy and fuel to rationalise the national subsidy burden. It also includes the role of the BERC to conduct and regulate the regular price adjustment to avoid energy subsidy. The necessity of proper pricing of fossil fuel energy products, to promote the generation and uses of renewable energy, is also laid out in the 8th FYP.

[2]The automated price model holds a similar essence to the administered pricing, which will be discussed later.

One of the key objectives of the National Energy Policy 2004 is to ensure reliable supply of energy to the people at reasonable and affordable price. The policy also emphasises on the creation of a competitive environment for giving the best deal to the consumers in price and quality for petroleum products.

Additionally, the IEPMP only mentions about energy demand forecast keeping the global energy price in mind. However, it does not include any plan or framework for justified electricity and fuel pricing in Bangladesh to phase out fossil fuel subsidy and energy transition. None of the other plans or policies such as MCPP, Perspective Plan or Renewable Energy Policy include the power and energy tariff in the discussion. Table 1 represents the reflection of energy pricing mechanism in the policies and plans of Bangladesh.

The BERC Act was designed to foster an investor-friendly, competitive, and transparent national energy market.[3] The clause number 34 of BERC Act sheds light on pricing issues. It included some specific clauses stating that notwithstanding anything contained in any other law for the time being in force, the price of power generation in wholesale, bulk and retail, and the supply of energy at the level of end-user, shall be determined in accordance with the policy and methodology made by the Commission in consultation with the government. At the time of making the policy, the Commission shall take into consideration some specific matters. The commission, by regulation, shall make methodology for tariff determination, and tariff determined by the Commission shall not be revised more than once in a fiscal year, unless there is change in the prices of energy including any other changes in the global energy market.

However, significant amendments to clause 34(a) of the BERC Act in 2020 and 2023 have substantially weakened BERC's authority (Preoty, et al., 2023).[4] The justifications provided for subsidy rationalisation appear vague, as they often rely on discretionary decisions by the authorities. For instance, reasons such as consumer welfare, agricultural demand, industrial and business needs and household consumptions do not offer a concrete basis for tariff adjustment. The reasons are defined broadly. Another main weakness of the new mechanism is that it does not promote transparency and accountability in price setting. By excluding public participation from the tariff adjustment process, the process limits oversight and fails to ensure transparency in decision-making.

The BPC Act 2016 (Act No. 8 of 2016) sets out composition, duties and responsibilities of the BPC and regulates its functions, powers, internal organisation and external relationships. The key activities of the BPC include the collection, importation and selling of crude petroleum and other refined petroleum products. By law, the activities do not include the price determination of petroleum products including petroleum oil in Bangladesh. Surprisingly, the BPC has been given the responsibility to set the price of fuel oil for more than a decade, even under the administrative pricing regime.

[3]The Act provides BERC with the authority to conduct energy audits, implement standardisation criteria for equipment, introduce competitive bidding to break monopolies, and issue licences following comprehensive assessments of energy-related activities such as power generation, transmission, distribution, supply, and storage. Additionally, BERC had the authority to enforce orders on private entities and Independent Power Producers (IPPs), impose penalties for discrepancies, and establish a complaint cell for issues related to energy usage. The agency was also responsible for renewing licenses of institutions annually based on their performance. Through such authority, BERC was able to hold the government regulatory bodies, power plant owners, public, private companies, joint ventures accountable for their actions and ensure public's involvement through public hearings.

[4]The amendment clause 34 A of BERC Act 2003 was repealed by the interim government to empower BERC again in case of tariff determination of energy and power.

Table 1: Reflection of Energy Pricing in Various Policy Documents

Policies/plans	Pricing issues mentioned in policy/plan documents		
	Goals/objectives	**Instruments**	**Institutions**
8th FYP	• Justified and proper pricing of the energy and fuel to rationalise the national subsidy burden • BERC to conduct and regulate the regular price adjustment to avoid energy subsidy	Not mentioned	BERC
IEPMP	• Only energy demand forecast keeping the global energy price in mind	Not mentioned	MoPEMR
MCPP	Absent		
Perspective Plan	Absent		
National Energy Policy	• To ensure reliable supply of energy to the people at reasonable and affordable price • To enable competitive market environment for giving the best deal to the consumer in price and quality	Not mentioned	BERC
RE Policy	Absent		
BERC Act 2003	• The price of power generation – at wholesale, bulk and retail levels – as well as the supply of energy to end-users shall be determined in accordance with the policy and methodology made by the Commission in consultation with the Government. • At the time of making the policy, the Commission shall take into consideration some specific matters. • Commission by regulation shall make methodology for determination of tariff Tariff determined by the Commission shall not be revised more than once in a fiscal year, unless there is change in the prices of energy including any other changes.	Guidelines of the commission Discussion with the ministry	BERC
BERC Act 2023	• The tariff revision is rationalised based on few factors such as for subsidy rationalisation, for consumers' betterment, demand of agriculture, industry, business and household, for uninterrupted power supply, expansion of transmission and distribution system, storage • Under the new mechanism, the public organisations do not need to disclose their financial state to justify the price adjustment • There is no room for accountability from government's side to explain the reasons for multiple and frequent price hike in details	Not mentioned	MoPEMR
BPC Act	Absent		

Source: Authors' Findings.

2.1.2 Energy related public institutions and their focus on energy pricing

Bangladesh Energy Regulatory Commission (BERC): The BERC has the mandate to regulate Electricity, Gas and Petroleum products for the whole of Bangladesh. The BERC was established through a legislative Act of the Government of Bangladesh on March 2003. The interim government restrained BERC's authority to adjust gas and electricity prices and dismissed the power of the ministry to revise tariff without holding public hearings and permit multiple tariff changes within a single year.

The BERC has also been assigned the responsibility of determining jet oil and furnace oil price from September 2024 through public hearings. Given the fact that BERC is updating the draft commission for fuel oil and petroleum product prices and will submit for the review and approval to the ministry. Previously, there was no regulation of the fuel oil price which held back the ministry from allowing the BERC to determine the fuel oil price. Although, previously during 2012, a draft regulation on the prices determination of petroleum products by the BERC was submitted, it was denied by the ministry at that time. The BERC has already a commission mandate for LPG and electricity price determination through public hearings.

The BERC has a major role to play under the International Monetary Fund's (IMF) condition of adopting the market-based pricing mechanism to determine, monitor and adjust the prices regularly (Moazzem et al., 2024). As a regulatory commission, BERC's role is essential for implementing the periodic market-based pricing system. Hence, re-establishing BERC's institutional power is highly needed as part of moving towards a transparent and accountable power and energy sector.

Bangladesh Petroleum Corporation (BPC): The main activities of the BPC are to supervise, coordinate and control the fuel oil import-related activities, fuel storing, marketing, and distribution of petroleum products in the country. Along with that, the BPC also develops and establishes infrastructure facilities to deal the port of loading (POL). As the BPC has been setting the petroleum price historically, it remains unclear which guidelines, acts, laws, rules or ordinances govern this process, as price determination is not officially part of BPC's mandate. The BPC's price calculation mechanism is unclear, with several hidden charges that lack proper justification. This report details out the faults and discrepancies in the later part of the report (see section 4). These opaque pricing mechanisms raise concerns about the methodology employed by the BPC, with even the BERC lacking full clarity on the rationale behind these practices.[5] To enhance transparency and fairness, the BPC should publicly disclose its pricing methodology and eliminate hidden charges.

2.2 Supply Chains of the Energy Market of Bangladesh: Focus on Fuel Pricing

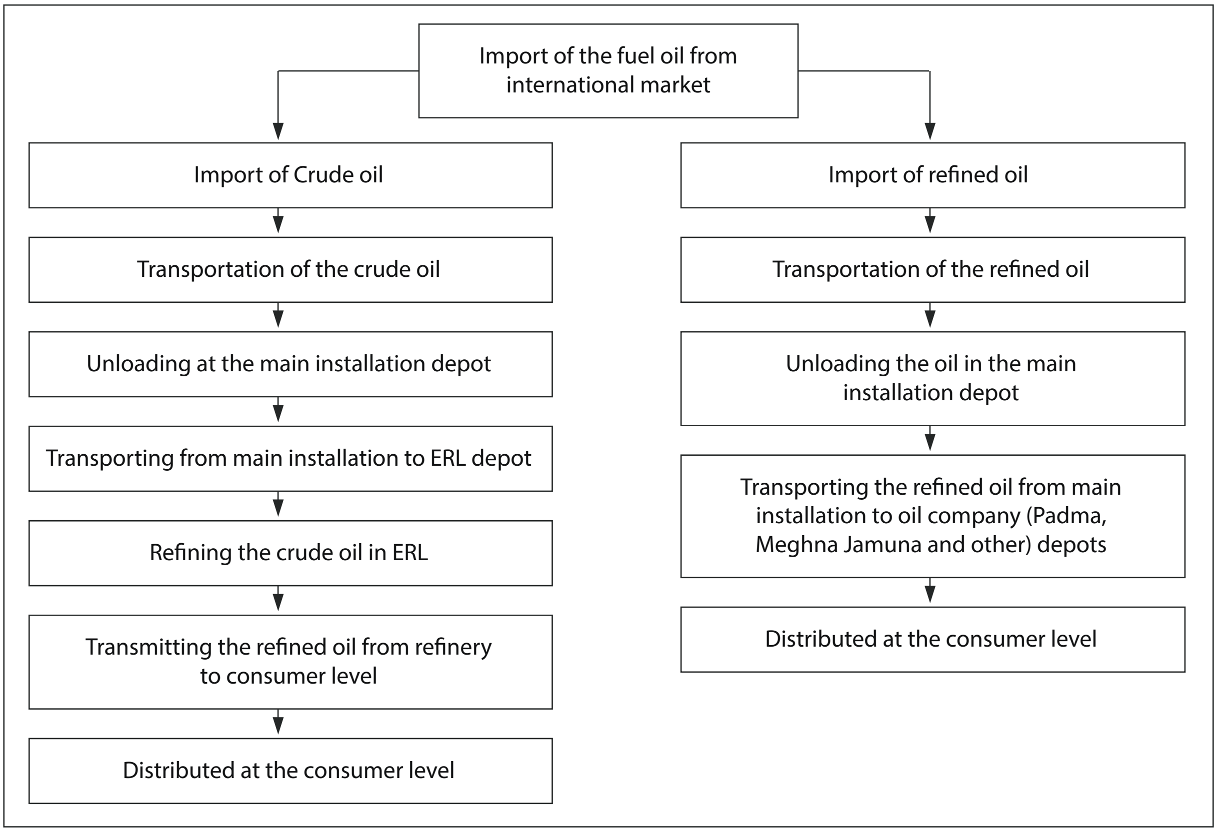
2.2.1 Diesel/Octane/Furnace Oil related Supply Chains (including cross-border pipeline) and Role of Market Agents in Fuel Pricing

The liquid fuel market of Bangladesh is predominantly import-based, with some additional domestic sourcing of fuel as a by-product of gas exploration. The BPC is the sole importer, regulator and implementing authority. The BPC imports the nationally required refined fuel oil (octane, diesel, petrol, and kerosene), determines the price and also sell it within the domestic market. This government body also imports crude oil and refine it at the country's only state-owned oil refinery named Eastern Refinery Limited (ERL). However, domestic refining capacity is limited, because the ERL can process 15 lakh tonnes of crude oil a year.

The supply chain of fuel oil includes two streams as Bangladesh import both crude oil and refined oil. According to the BERC officials, around 20 per cent of the fuel oil demand is being met by the crude oil refined in the ERL. The majority, 80 per cent, of the national fuel oil demand is met by the imported

[5]According to an interview with the senior officials of BERC (August 2024).

Figure 1: Supply Chain of Fuel Oil in Bangladesh



Source: Authors' Illustration.

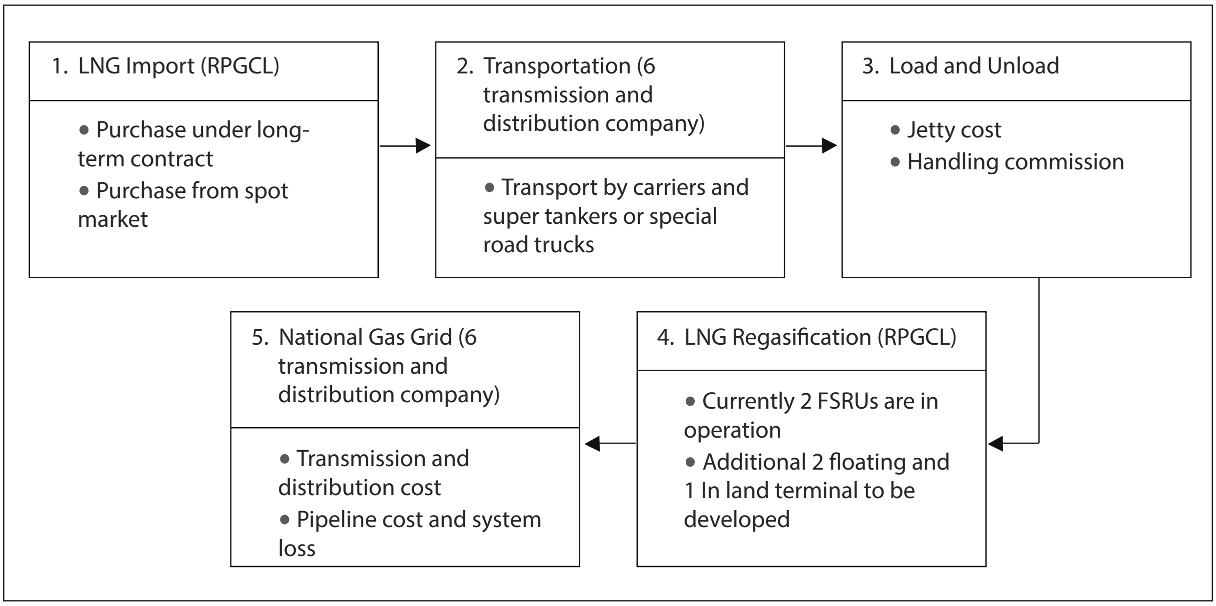
refined fuel oil. As shown in figure 1, the chain begins with the import of fuel oil from the international market. The liquid fuel oil is purchased based on the long or short-term contracts made by the BPC with the supplying company, specifying the volume and value of the oil. After the purchase of the crude or refined oil, the oil is shipped from the supplying country and headed towards Bangladesh, particularly at Chittagong seaport. It usually takes more than 10 days for the oil to be shipped in Bangladesh. Once the shipment reaches to the port, the oil is unloaded in the respective depots. In case of the crude oil, it is unloaded in the ERL depot and the refined oil is directly loaded to the depots of different oil companies such as Padma, Meghna and Jamuna Company Limited. Both the depots are located at the Chittagong seaport. Next, the state-owned oil companies distribute the oil at the consumer level through different oil pump stations. On the other hand, the crude oil is refined at the ERL and then is distributed at the consumer levels through oil pump stations.

Overall, fuel price apart from the import cost and shipment cost are determined at different domestic level including costs of loading-unloading, depot installation, refinery (in case of crude oil) and transmission and distribution at the consumer level.

2.2.2 Gas/LNG related Supply Chain and Role of Market Agents in Fuel Pricing

The supply chain of LNG in Bangladesh consists of five stages starting from import and ends at final consumers. Imported LNG goes through the process of regasification and regasified LNG is transferred

Figure 2: Supply chain of LNG import in Bangladesh



Source: Authors' Illustration.

into the national gas grid (Figure 2). Since an established gas grid is functional which is based on domestic gas, imported LNG is transmitted and distributed using this national gas grid. Rupantarita Prakritik Gas Company Limited (RPGCL), a subsidiary of Petrobangla is the responsible agency. The RPGCL is mainly established to conduct LNG-related import and trade operations in the country. Bangladesh imports LNG under both long-term contracts and procures from the spot market through RPGCL. Bangladesh currently has two long-term contracts—one with Qatar and one with Oman. The RPGCL has signed agreements with 23 companies to import LNG from the spot market as of September 2024. Bangladesh has imported 23 cargos from Qatar's Ras Laffan Liquefied Gas Company Limited and has imported 9 cargos from Oman Trading International (OTI). From spot market a total of 68 Cargoes of LNG has been imported till July 2024.

There are two operational LNG terminals near Moheshkhali Island in Cox's Bazar, both are Floating Storage Regasification Units (FSRUs). These two FSRUs have a capacity of 500 million standard cubic feet per day (MMSCFD) each. Expansion of the capacity of the existing FSRUs was included in the plan of the earlier government from 500mmcft to 630mmcft per day.[6]

A pipeline has been built to connect the FSRUs to the national gas grid, allowing re-gasified LNG to be transported through it. Gas Transmission Company Limited (GTCL), a subsidiary of the Bangladesh Oil, Gas & Mineral Corporation (Petrobangla), is the sole entity responsible for gas transmission in the country. The six gas distribution companies – Gas Transmission Company Limited (GTCL), Titas Gas Transmission and Distribution Company Limited (TGDCL), Jalalabad Gas Transmission and Distribution Systems Limited (JGTDSL), Bakhrabad Gas Systems Limited (BGSL), Pashchimanchal Gas Company

[6]The previous government had a plan to establish three additional liquefied natural gas (LNG) terminals alongside the existing two for re-gasifying imported gas. Two of these are supposed to be located in Moheshkhali and Matarbari in Cox's Bazar, while the third will be at Payra, with two being floating and one land-based.

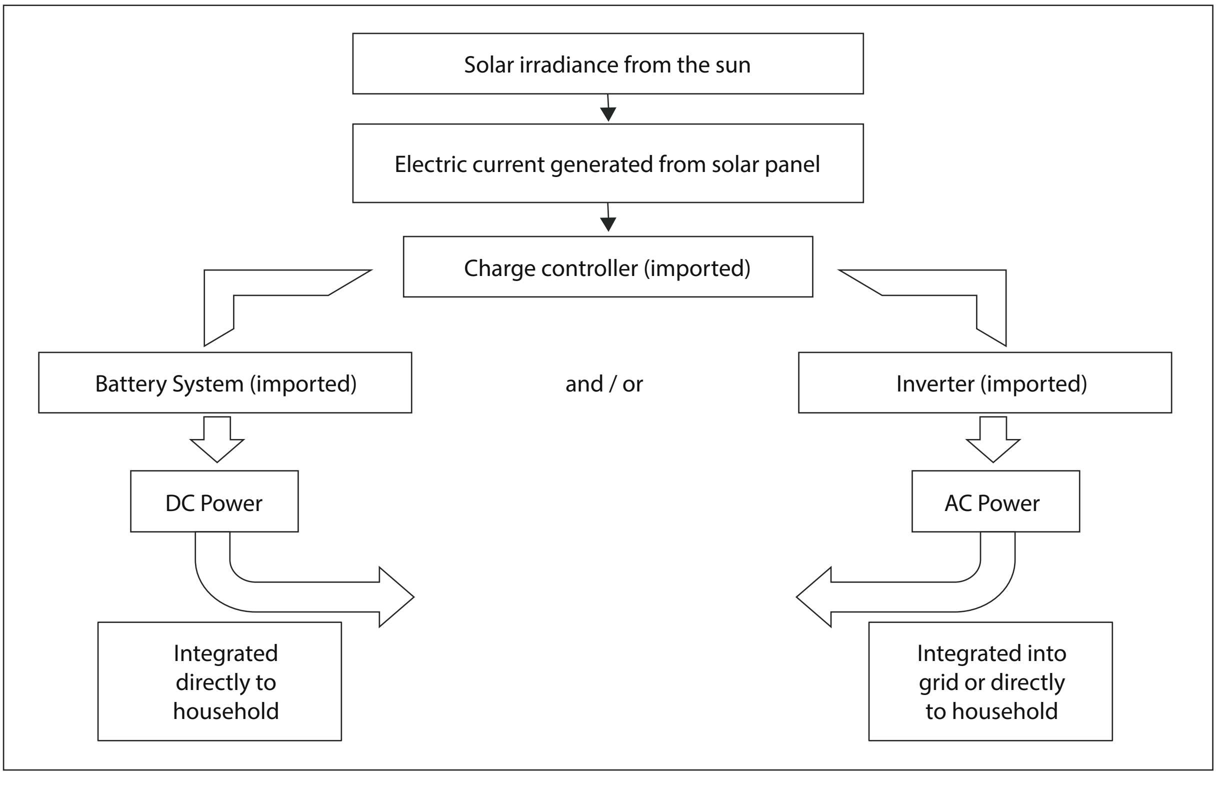
Limited (PGCL), and Karnaphuli Gas Distribution Company Limited (KGDCL) – are all subsidiaries of Petrobangla.

Overall, apart from the import and shipment costs, the LNG price is determined by the transportation cost, loading and unloading cost, cost of regasification, and grid transmission and distribution costs at different domestic consumer levels.

2.2.3 Renewable Energy-related Supply Chain and Role of Market Agents in Fuel Pricing

The renewable energy sector of Bangladesh is largely dependent on solar energy. The supply chain of solar energy in Bangladesh (Figure 3) is similar to that of the global supply chain. Figure 3 demonstrates the solar supply chain in the case of power generation. As solar or any other renewable source of energy as a fuel is free of cost, it sets the supply chain apart from other fuels. The cost component of solar energy begins with the cost of solar panels which are imported into the country. The supply chain of solar is also divided into two streams. One is direct integration into the smart grid through inverter and another is storing through the battery system and then feeding into the grid system. These components and equipment are all imported. As the cost component of the battery system is much higher, it drives up the cost of solar power at the consumer's end.

Figure 3: Supply Chain of Fuel Oil in Bangladesh



Source: Authors' Illustration.

2.3 Scopes for Trade and Investment of Australia in the Renewable Energy Sector of Bangladesh

Bangladesh and Australia have maintained a sustainable economic partnership over the years. Australia and Bangladesh are pursuing new opportunities to promote trade and investment under the Australia-Bangladesh Trade and Investment Framework Arrangement. Australia is also one of the major Foreign Direct Investment (FDI) providing countries for Bangladesh (Table 2). Australia's major FDI in Bangladesh is in the gas and petroleum sector, accounting for 99 per cent of its total FDI stock.

Table 2: FDI by Australia in Major Sectors in December 2023

Major Sectors	FDI Stock (million USD)
Textile and wearing	0.15
Gas & petroleum	647.84
Banking	0.00
Power	0.00
Telecommunication	0.00
Food	0.00
Trading	0.44
Chemicals and pharmaceuticals	0.53
Agriculture and fishing	0.02
Leather and leather products	2.84
Construction	0.00
Insurance	0.00
NBFI	-10.01
Cement	0.00
Fertiliser	0.00
Other sectors	8.29
Total FDI stocks	650.10

Source: Bangladesh Bank Investment Report 2023.

However, Australia still has not initiated renewable or clean energy investment in Bangladesh. The Australian government is working with countries in the Indo-Pacific to support deployment of a range of renewable technologies, including solar, wind, hydropower and biomass, as well as support for improved energy efficiency, which contributes to Paris Agreement goals. Australia is co-funding the Tonga Renewable Energy Program, helping Tonga meet its target of 100 per cent renewable energy by 2035. Since 2020, Australia is also working with Solomon Island Electricity Authority to facilitate the construction of a 22-kilometre transmission line connecting the Tina River hydropower site to the electricity grid in Honiara, the Solomon Islands capital. While challenges remain in the case of business environment and ease of doing business, Bangladesh offers potential long term commercial opportunities to Australian companies operating in education services, food and beverages, agri-business and energy, and minerals. There are windows of opportunity for the Australian businesses that provide services and equipment for energy and infrastructure developments.

In 2020, Australia released its first 'Low Emissions Technology Statement' as part of its Technology Investment Roadmap. The goal is to establish a prosperous Australia, recognised globally as a leader in low-emissions technology. The strategic focus of this initiative is to accelerate the development of new and emerging technologies, making them economically competitive with established ones, and unlocking new opportunities across the country. It aims to build on Australia's role as a trusted exporter of energy, resources, and agricultural products, ensuring continued prosperity in a low-emissions global economy. The initiative also envisions a lasting partnership between industry, investors, researchers, and governments to drive energy transition and renewable energy. According to the Ministers for the Department of Industry, Science and Resources, the Australian government has committed 20 billion Australian Dollars in investment towards low-emissions technologies over the next decade, until 2030. At the time, the former Australian High Commissioner to Bangladesh expressed a commitment to promote a clean-energy supply chain initiative in the Indo-Pacific region and supporting countries like Bangladesh with energy resources, including renewable energy, to fuel the nation's growth.

As Australia works to meet its commitments and assists its partners in achieving their targets by scaling up clean-energy technologies at competitive costs, Bangladesh has the opportunity to leverage this opportunity to expand its own clean energy sector. Such a partnership could enable Bangladesh to develop low-cost, highly effective solar, wind, and hydro energy technologies within its borders. A long-term emissions reduction strategy can be established, outlining how Australia can support Bangladesh in adopting low-emissions and energy-efficient technologies to fulfil its energy transition commitments while ensuring a reliable supply of clean energy. With Bangladesh now placing greater emphasis on energy transition, there is limited potential for Australia to invest in or trade fossil fuels and fossil fuel-based technologies under the new political regime.

3. ANALYSIS OF SUBSIDY IN THE POWER AND ENERGY SECTOR AND ITS IMPLICATIONS ON COMPETITIVE FUEL PRICING

In Bangladesh, the power and energy sector receives the largest share of subsidies, aimed at alleviating the cost burden for mass consumers in the power sector. However, a significant portion of this subsidy stems from issues with the pricing policy and capacity payments made to power plants. The amount of subsidised credit has been increasing drastically from BDT 4,000 crores in FY2017 to BDT 23,000 crores in FY2023. It reached BDT 32,000 crores in FY2024 and further increase to BDT 40,000 crores in FY2025. This substantial subsidised credit has made the sector one of the largest recipients of government subsidies, accounting for 37.9 per cent of the total subsidy. The credit is primarily used to cover large capacity payments owed to independent power producers (IPPs), quick rental power plants, and other private entities.

The economic impact of energy subsidies involves a complex series of changes in resource allocation, associating costs and prices, while also leading to a wide range of economic, social, and environmental outcomes. Subsidising power and energy sector to ensure affordable access for the masses is a common practice in developing countries. Many net energy-importing nations have implemented various subsidies in local markets to cope with the recent global surge in energy prices. In Bangladesh, large energy subsidies make the country's fiscal position highly vulnerable to fluctuations in global energy prices. When global fuel prices rise, the government faces a choice between raising domestic fuel prices or increasing subsidies to offset the global price hikes. While increasing prices is politically challenging and could trigger inflation, increasing subsidies distorts the economy and limits development options. Evidence suggests that the subsidies provided to the power and energy sector have negatively impacted public welfare, as the growing subsidy burden reduces the funds available for other priority sectors like health, education, and social safety net programmes (Granado et. al. 2012 & Dipa et. al. 2015).

3.1 Financial Account of the BPC

The BPC does not receive subsidy from the MoPEMR anymore, starting from FY2014-15 of national budget of Bangladesh. After FY2015, the BPC was not allocated any subsidy amount (Table 3). Even when the BPC incurred loss during the Covid-19 pandemic due to the global fuel oil price, no subsidy or loan was provided. The organisation has been adjusting its loss through incremental price adjustments and making profits for the last few years. The detailed estimates and analysis on how tariffs are set on a high margin compared to import cost and production cost of fuel are provided later on this section demonstrating the mechanism of loss adjustment of the BPC.

Table 3: Financial Account of the BPC (2023)

Issues	Amount (in crore BDT)
Revenue	79187.5
Expenditure	183.6
Profit/Loss	4586.1
Subsidy	0.0

Source: BPC Annual Report (2024).

Under the administered pricing regime, a wide range of discrepancy within the import cost and tariff of fuel oil can be observed. Table 4 represents that the fuel oils diesel, kerosene, petrol and furnace oil are being sold at a wide margin. The selling tariff has been set at a higher rate compared to the import cost or oil refining cost of the BPC. It is yielding profit in all type of oil.

Table 4: Discrepancy Between Fuel Oil Import Price and Tariff

Product Name	Local Selling Price (BDT/litre)	Import cost per litre (BDT/litre)	Selling Tariff	Difference Between Cost and Price
HSD (Diesel)	105.50	50.00	95.00	10.50
SKO (Kerosene)	105.50	50.00	97.40	8.10
MS (Petrol)	121.00	60.68	109.68	11.32
FO (Furnace Oil)	86.00	42.29	85.29	0.71

Source: BPC (2024).

As mentioned before, no subsidy has been provided for the diesel, petrol or octane import over the years. As table 5 demonstrates, there is a trend of incremental profit obtained by BPC throughout the years. BPC has incurred loss only in 2022 due to the global price hike. However, the loss was adjusted once again by increasing the tariff by minimum of BDT 25 per litre to as high as BDT 44 per litre. Given to the price increment BPC was in profit in the following year 2023. Even if BPC did not receive subsidy, the upward tariff revision under the administrative pricing regime made it profitable for the BPC to import and sell fuel oil by passing the burden onto the consumers' shoulders.

Table 5: Trend of Tariff Adjustment and Relationship with Subsidy

Years	Incremental tariff (BDT/litre)			Incremental revenue or loss (BDT/Crore)	Amount of subsidy required (BDT/Crore)
	Diesel	Petrol	Octane		
2020	0	0	0	5065.3	0
2021	15	0	0	6493.7	0
2022	34	44	25	-2705.64	0
2023	-5	-5	-5	4586.09	0

Source: Authors calculation from BPC retail price data and MoF data.

In conclusion, given the fiscal constraints as well as fiscal pressure in most of the developing countries including Bangladesh, utilising such a large amount of subsidy in the energy sector would further squeeze the resource availability for the social sectors. Hence, the social sectors are deprived of getting sufficient funds for making necessary investments. Additionally, the over-consumption of imported fuels resulting from subsidised prices leads to increased demand, which may contribute to a decline in the country's balance of payments and increase its dependence on imported fuels. Moreover, when subsidies rise quickly, the government may be forced to divert resources from other productive activities or resort to borrowing. Overall, the economy may be exposed to inefficiencies in both the allocation and distribution of resources across different sectors and activities. Selling imported fuel at the price below the global level in the domestic market induces losses for the BPC. However, now the BPC has a surplus value as a result of selling the oil price higher than the international market. The consequence of upward tariff revision can have a much adverse impact on the mass population in countries like Bangladesh that lack in terms of effective safety net programmes.

3.2 Financial Account of Petrobangla and RPGCL

The responsible government body is entitled to all the import and financial cost incurred by BPC and RPGCL. Historically, Petrobangla is in red given the high import cost of fossil fuel. Even the provided subsidy cannot close the financial gap to near zero. Currently, only Petrobangla is receiving the subsidy among all the fuel energy-providing authorities (Table 6). The main reason for the provided subsidy to Petrobangla is mainly for LNG import by RPGCL. The high cost incurred due to the LNG purchase from spot market worth BDT 6000 crore has been provided to Petrobangla (table 6).

Table 6: Financial Account of the BPC, Petrobangla and RPGCL

	BDT in Crore			
	Revenue	Expenditure	Profit/ Loss	Subsidy
Petrobangla (2022)	21,771	47,095	-16,299	6000
RPGCL (2023)	57.66	11.46	26.60	0

Source: Annual Reports of BPC, Petrobangla and RPGCL.

To reduce the subsidy burden, the government has increased the gas price at the retail level in different sectors from February 2023 and exactly after 1 year of gas tariff for private and captive power producers were increased in February 2024. The gas tariff for public, IPPs and rental power plants has been increased by 194 per cent. This sector has witnessed the highest price hike followed by small, cottage and other industry 178 per cent (Table 7), whereas the captive power experienced the lowest price hike

92 per cent. Such power non-proportional and discriminatory tariff adjustment indicates the unfair and unjust distribution of subsidy across different consumer class.

Table 7: Trend of Sector Gas Price Hike

Sectors	Previous Tarif (BDT/ cubic metre)	New Tariff (BDT/ cubic metre)	% Change
Power (Public, IPP, Rental)	5.02	14.75	194
Captive Power	16.00	30.75	92
Large Industry	11.98	30.00	150
Medium Industry	11.78	30.00	155
Small, cottage and other Industry	10.78	30.00	178
Commercial (Hotel & Restaurant)	26.64	30.50	14

Source: BERC Gas Price Gazette.

However, the price of electricity generated from fuel oil is subsidised by the government. With that being said, the major portion of subsidy in the power sector of Bangladesh is mainly driven by the LNG-based electricity generation. Such hefty subsidy is imposing a sufficient fiscal burden on the national reserve and balance of payment. Previous literatures found that, as in other countries similar to Bangladesh, energy subsidies impose a significant fiscal burden, with benefits disproportionately favouring high-income households (McKitrick (2017), Rao (2012)). Using a computable general equilibrium model, Timilsina, et al., (2020) investigated the economy-wide impacts of the removal of direct subsidies in the electricity sector and indirect subsidy in natural gas in Bangladesh. The study found that the removal of energy subsidies would be beneficial to the economy and would increase the Gross Domestic Product (GDP). The magnitude of the economic impact depends on how the budgetary savings from the removal of electricity subsidies and the increased revenues due to the removal of indirect subsidies to natural gas are reallocated to the economy. Recycling the savings from subsidy reduction to fund investment would benefit the country's renewable energy transition the most (Yang et. al (2019) & Matallah et. al (2023)).

3.3 Inflation Driven by Fuel Oil Price

An on-going research by the CPD, utilising over 40 years of historical data in Bangladesh, has revealed distinctive inflation dynamics in relation to global fuel oil prices. Employing a Vector Autoregressive Model, the study finds that non-food inflation from the Consumer Price Index (CPI) exhibits a strong and significant positive association with global fuel oil prices.

The CPI can be broadly divided into food and non-food components. The latter includes several critical sectors such as transport, communication, electricity, housing (excluding rent), medical care, and recreational services. The study highlights that while food inflation remains largely uncorrelated, non-food sectors react more significantly to changes in global oil prices. For instance, transportation, which is heavily reliant on fuel, directly transmits oil price volatilities to consumer costs (Maitra, et al., 2021).[7]

[7]EBL Securities Ltd. (2017) highlighted that 46.5% of fuel oil is consumed in the transportation sector, 25.7% of the fuel oil is consumed in the power sector, 17.5% of the fuel is consumed in agriculture, 4.3% of fuel is consumed in the industry sector and the rest is consumed in other domestic sectors.

Similarly, electricity tariffs, often linked to fuel costs in Bangladesh where oil-powered generators are common, also contribute to this trend (Luo & Ye, 2024). The result has been a reason for distorted market where domestic users and industries struggle to gain competitiveness. Such distortions might have entrenched an uneven economic landscape, disadvantaging consumers and preventing the efficient allocation of resources.

4. ANALYSIS OF INTERNATIONAL PRACTICES OF MARKET-BASED ENERGY PRICING MECHANISMS

The synthesis of advanced analytical methodologies provides critical insights that are indispensable for both policymakers and market participants in setting the energy pricing within the complicated market structure. The literature spans a range of sophisticated models, each contributing uniquely to the understanding and forecasting of dynamic and often volatile energy markets.

(a) Neural Networks and Fuzzy Logic

Anders & Rodriguez (2004) integrated Neural Networks and Fuzzy Logic to represent a significant advancement in predictive analytics within the energy sector. Neural Networks are particularly adept at modelling non-linear relationships which are common in energy prices due to their susceptibility to numerous influencing factors like policy changes, natural events, and market dynamics. Fuzzy Logic adds an ability to handle uncertainty and imprecision, making the model robust against the inherent volatility of energy markets. The application to formulate optimal bidding strategies for generators reflects a practical and tailored approach, addressing specific risk profiles. However, the dependency on extensive and accurate data for training these models is a notable limitation, as poor data quality can significantly impair the model's performance and output accuracy.

Neural Networks, as further explored by Malliaris and Malliaris (2008) and other subsequent studies, are crucial for energy price forecasting due to their ability to process and learn from large datasets, capturing complex patterns that are not apparent through traditional statistical methods (Malliaris & Malliaris, 2008). Neural Networks excel in environments where relationships between variables are hidden and not well understood. The importance of Neural Networks in energy pricing lies in their adaptability and learning capability, which allows them to improve continually as more data becomes available. However, the complexity of these networks can also be a drawback, as they require extensive computational resources and expertise to set up and maintain. Moreover, they can be 'black boxes', providing little insight into how decisions are made, which can be a barrier in settings that demand transparency. Additional contributions from Wang & Ramsay (1998), Gao, et al. (2000) and Szkuta, Sanabria, & Dillon (1999) focused on the predictive capabilities of Neural Networks across different markets including England-Wales, California, and Victoria, Australia, respectively. Although one experimental result by Gao, Lo, & Fan, (2017) suggested that the ARIMA model gives greater improvement over persistence than the artificial neural network (ANN) model, ARIMA model is subject to vulnerability and sensitivity.

(b) Time-series Based Models (Dynamic Regression, Transfer Functions and ARIMA)

The use of Dynamic Regression and Transfer Function Models by Nogales et al. (2022) introduces another layer of sophistication in forecasting and estimating an accurate pricing figure, focusing on the temporal relationships and dynamic adjustments over time. These models are praised for their accuracy in reflecting market realities through time series analysis, which is particularly suited for the recurrent patterns and trends observed in energy markets (Nogales, et al., 2022). Despite their effectiveness, these models require stringent assumptions about the stationarity and linearity of data, which can be a constraining factor given the frequent shocks and anomalies in energy price data.

Contreras & Santos (2006) emphasised the efficacy of time series-based models such as ARIMA, Dynamic Regression, and Transfer Function models, highlighting their superiority in the context of energy pricing forecasts. These models are particularly renowned for their ability to capture and analyse the time-dependent structure of data, which is a fundamental characteristic of energy markets where prices are influenced by past values and trends. The strength of these models lies in their rigorous statistical foundation, where maintaining a significance level below 5 per cent is crucial. This level of statistical significance ensures that the forecasts made are not just by chance, thereby providing a reliable basis for decision-making. Reliability is particularly paramount in energy markets that are subject to rapid changes due to external shocks such as regulatory changes, geopolitical events, or natural disasters. However, the potential limitations of these models include their reliance on the assumption that historical patterns will continue into the future, which may not always hold in highly volatile or evolving markets. Additionally, these models can be complex to configure and require regular updates to model parameters to maintain accuracy over time.

(c) Jump Diffusion/Mean Reversion Brownian Motion Model

Skantze, Ilic, & Chapman (2000) utilised the Jump Diffusion/Mean Reversion Brownian Motion Model to predict energy prices in the Californian Energy Market. This model incorporates elements of stochastic processes to better represent the random nature of price movements. They acknowledge that prices do not simply follow smooth or predictable paths but are instead subject to jumps and abrupt changes (Skantze, Ilic, & Chapman, 2000). The Jump Diffusion component of the model is particularly adept at handling sudden spikes or drops in prices, which are common in energy markets due to unexpected changes in supply, demand, or policy. Meanwhile, the Mean Reversion aspect suggests that prices will tend to return to a long-term mean which provide a balance by moderating the long-term forecasts that might otherwise veer too far from historical norms. This model's application to the Californian market is significant, as this market has been historically volatile and influenced by a variety of factors such as environmental regulations and technological changes in energy production (Skantze, Ilic, & Chapman, 2000). Despite its advantages, this model also faces challenges. Primarily, the challenge entails the complexity involved in accurately estimating the parameters for jump and reversion processes. Furthermore, the assumption of mean reversion might not hold in markets undergoing structural changes, leading to potential inaccuracies if the long-term mean changes over time.

(d) Analytic Network Process

Iskin, Daim, Kayakutlu, & Altuntas (2012) used the Analytic Network Process was employed to examine social, technical, environmental, and economic factors influencing energy pricing, focusing on comparative analysis between the United States and Turkey. The novelty of the model lies in its ability to handle inter-dependencies and feedback within clusters of criteria, which are critical in the multifaceted energy sector where factors are often interlinked. However, the major drawback noted in their study is the absence of empirical validation, which raises concerns about the practical applicability and reliability of the theoretical model proposed. Without empirical analysis, the theoretical constructs remain untested in real-world scenarios, which is a critical gap for stakeholders relying on these forecasts for strategic decisions.

(e) Univariate Dynamic Harmonic Regression

Pedregal & Trapero (2007) enhance a novel univariate dynamic harmonic regression model set in a state space framework, designed to adeptly handle the complexities of evolving electricity markets to forecast electricity prices in a market setting. This model leverages the frequency domain for rapid automatic identification and estimation, providing valuable insights into trends and cyclical patterns crucial for strategic management in electricity companies. However, it faces potential limitations in highly volatile markets where abrupt changes driven by external factors might not be swiftly captured due to its dependency on historical frequency analysis. In contrast, Neural Networks (NNs), with their capability to model complex nonlinear relationships and adapt continuously through deep learning from extensive datasets, might offer superior flexibility and accuracy, particularly in environments where market dynamics are unpredictable, and data is abundant. This makes NNs a potentially more robust choice for adapting to rapid market changes without the need for predefined assumptions about data structures.

Table 8: Summary of Advanced Models Utilised in Various Power and Energy Markets across the World

Market Name	Model Names					
	Neural Network (NN)	Dynamic Regression (DR)	Transfer Function	ARIMA	GARCH	Jump Diffusion
Ontario electricity market	Yes and Fuzzy Logic					
Spanish electricity market		Yes	Yes	Yes	Yes	
Norwegian electricity market			Yes	Yes	Yes	
California electricity market		Yes	Yes			
Victorian wholesale market	Yes					Yes
England and Wales pool	Yes					

Source: Authors' compilation.

In summary, incorporating socioeconomic factors such as consumer behaviour, economic conditions, and policy changes into energy pricing models significantly enhances their relevance and predictive accuracy (table 8). Traditional models like ARIMA and Analytic Network Processes, while structured and capable of analysing historical data trends, often lack flexibility and empirical validation, limiting their effectiveness in rapidly changing markets. On the other hand, Neural Networks and Fuzzy Logic are better equipped to manage the nonlinear dynamics and uncertainties of volatile energy markets due to their ability to process complex, multidimensional data. This makes Neural Networks particularly adept at integrating diverse socioeconomic indicators, offering a robust solution where traditional models falter. Stochastic models also play a vital role in addressing price volatility through sophisticated parameter estimation techniques. Overall, the choice of a model should consider the ability to incorporate critical external factors, the demands of computational resources, and the specific needs of the energy market to ensure optimal accuracy and adaptability.

5. TRANSITION FROM ADMINISTERED TO MARKET-BASED PRICING SYSTEM

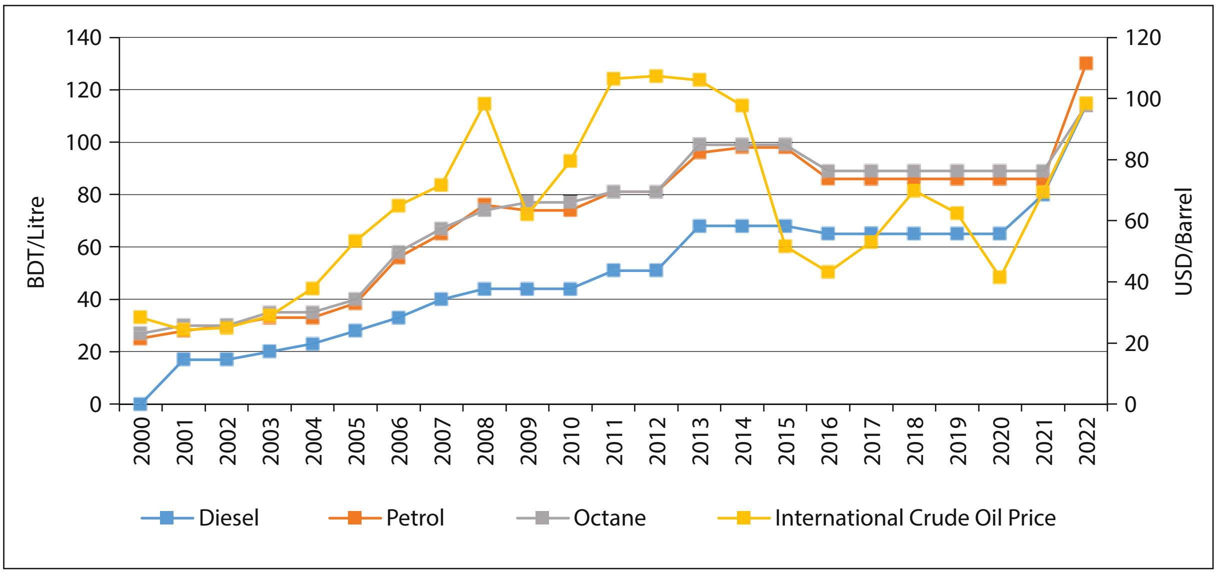
5.1 Historical Fuel-oil Price Trend under Administered Pricing System

Bangladesh government followed administrative pricing system for Bangladesh in accordance with Bangladesh Petroleum Act 1974 (Ahmed, Sattar, & Alam, 2018). Figure 4 shows historical price trend from 2000 to 2022. The retail price of fuel oils such as diesel, petrol and octane in the domestic market tends to have a historically upward trend. The domestic market price is supposed to have a relationship with the international market price. However, a volatile up-and-down trend is observed in the case of international crude oil prices. This lag is attributed to the administered pricing mechanism.

Figure 4 clearly shows several key points where the domestic prices of diesel, petrol, and octane do not decrease in tandem with a drop in international crude oil prices. For instance, a notable increase in administered prices was observed in 2018, a response by the BPC prompted by a surge in international crude oil prices. The BPC requested the government to increase the prices, which resulted in higher retail prices for diesel, petrol, and octane and the government approved their pleads (Rahman, 2018). This decision was likely influenced by the need to manage fiscal balances, considering the cost of importing crude oil and refined products. However, a persistent issue with the administered pricing system is its inflexibility in reducing prices when international rates fall, attributed to the BPC not requesting for an adjustment. This phenomenon was particularly evident in the post-2018, as international crude oil prices started to decline, yet domestic fuel prices remained elevated or decreased insignificantly.

The historical trend of diesel, octane, and petrol prices in Bangladesh, when compared to international crude oil prices, highlights the challenges of an administered pricing system. While this approach allows the government to manage economic and social policies more directly, it also leads to issues like delayed price adjustments.

Figure 4: Historical Price Trend of Domestic Fuel Oil and International Crude Oil Price



Source: Authors' calculation based on BPC and Trading Economics.

5.2 Automatic Fuel Oil Pricing System

The gazette on detailing out the new formula for automatic fuel pricing guidelines were published by the MoPEMR on 29 February 2024. Table 9 presents the summary of the government set fuel pricing formula.

Table 9: Automated Fuel Oil Pricing Formula

SL.	Particulars
A	1. Crude oil FOB rate (BDT per Litre)
	2. Premium freight, service charges (BDT per Litre)
	(A) Total Product Cost
B	Duty (BDT per litre): 5% for crude oil
	AIT (BDT per litre): 2% of tariff value
	(B) Total duty & taxes per litre in BDT
C	Handling Commission + Jetty Throughout Charge (BDT per Litre)
	River Dues (BDT per litre) + 15% VAT
	Survey Fee (BDT per Litre) - Standard Assumption
	Ocean Loss (BDT per Litre) 0.5% on FOB for crude oil
	L/C Commission + VAT (BDT per litre)
	Crude oil Processing Cost - Avg. Cost of ERL processing (BDT per litre)
	Crude oil process lost
	(c) Total Operational Expense (BDT per litre)
C1	Average cost (A+B+C) incurred for fuel oil (BDT per litre)
C2	Cost (BDT per litre) considering balancing factor for HSD: C1*1.14
D	Financing charges (BDT per litre)
	Administrative, maintenance & development expense (BDT per litre)
	(D) Total financing, administrative, maintenance & development expense (BDT per litre)
E	BPC's margin on C2+D (BDT per litre)
F1	Total cost: C2+D+E (BDT per litre)
F4	3. VAT 15% on F1
G1	Ex-refinery price after VAT (F1+F4)
G	4. Company margin, development fund and freight pool (BDT per litre): BDT 0.8 + BDT 0.25 + BDT 1.20
	5. Dealer's commission and transport (BDT per litre)
	6. Traders' 2% VAT on G1+4+5 (BDT per litre)
	(G) Total selling and distribution expenses (4+5+6)
H	(H) Selling Price (BDT per litre): G1+G

Source: Formula sourced from (MoPEMR, 2024).

The automated pricing model has a number of attributes which include (a) production cost; (b) duty and taxes; (c) operational expenses; (d) financing, administrative, maintenance & development expense; (e) BPC margin and VAT; (f) company margin, development fund and freight pool and (g) dealer's commission and transport.

5.3 Observations Regarding Automated Pricing System

According to energy experts, the new formula is not much different from the previous administrative formula except for some factors. There are so much of technical error in the adopted pricing mechanism. The new mechanism is in detailed form, but not all the factors are clear, and it still includes many flaws and limitations. As it appears that the understanding of the officials of the Division regarding price setting mechanism has several weaknesses.

Unethical practice of BPC's margin including product cost: The BPC margin includes all the previous indicators that include raw materials as well. The international best practice is not to include any margin on the raw materials, whether be it is oil, gas or water. This is against the BERC practice, as well. The raw materials only be bought at the market price and no margin shall be included on top of the raw material. The margin can be only on financing and investment as a form of return to investment or equity. There is a popular method, Weighted Average Cost of Capital (WACC). International practice is to calculate margin as a return on investment or equity only and excluding product cost, VAT and duty.

The anomalies in determining conversion rates: The formula includes several per cent points as rates, but the consideration of such rates is unclear. The 9 per cent financing charges per litre seems too high and the clarification of considering such number is not provided. Similarly, the basis of the letter of credit (LC) commission, transit loss, crude oil processing loss needs to be reviewed and verified that how the BPC determines the basis of such factors.

Upward adjustment of exchange rate: The determination of the exchange rate is very crucial as it is the key component for imported oil from international markets. The BERC takes the weighted average of LC settlement for the previous month. The BERC particularly uses the LC settlement rate of Sonali bank for LPG pricing. However, it is unclear which exchange rate BPC uses for pricing, as exchange rates are volatile, and different banks may settle LCs at varying rates, leading to inconsistencies in determining the final exchange rate for oil imports.

Unclear factors included in the pricing formula: Premium/ freight is determined based on whether the oil is transported through trader or being transported directly from the exporter. If the oil is traded through a trader, then the premium/freight cost will be higher. In addition to that, cost considering balancing factor for the high-speed diesel (HSD) is unclear, given the fact that it is not mentioned that what is there to balance for the BPC.

Duty, AIT & differential VAT: The state-owned companies usually adjust the advance income tax (AIT) with the tax return such as the Bangladesh Power Development Board (BPDB). It is important to know whether the BPC pays corporate income tax or not. Other taxes and duties are determined by the National Bureau of Revenue (NBR) rates. The multi-layered imposition of tax and VAT raises an issue because the burden of the ultimate and final price is passed on to the consumers.

Crude oil processing charge: The formula states BDT 1.53 as average cost per litre of Eastern Refinery Limited (ERL), it is important to check the audit report of ERL to check the average cost of crude of processing. Similarly, selling and distribution expenses rates need to be verified and justified from the BPC and other oil company audit reports.

Impact on revenue collection: The adjustment of tax and duty is not reflected in the pricing mechanism. However, it is essential to moderate the impact of price fluctuation in the domestic market. Countries that follow the automatic pricing system, even India, adjusts the VAT and duty structure if the oil price soars in the international market to keep the domestic price on a bearable level. However, such moderation and adjustment are not reflected in the newly adopted methodology. One of the key reasons is to keep the revenue flow intact as 54 per cent of NBR's revenue generation is earned from imported fuel oil.

BPC working as an administrator: The monitoring of the BPC as both importing and implementation authority has repeatedly been questioned. The BPC working as both importer and regulator questions the credibility of the system. On the other hand, the regulation and price determination of LPG by the BERC has been considered as a standard process of setting the energy prices. The BERC has been suggested as the regulatory and implementing authority of the petroleum oil prices as well.

5.4 Automated Pricing Formula Proposed by the BERC

The pricing formula proposed by the BERC is given in Table 10.

Table 10: Automated Pricing Formula of Retail Fuel Oil Proposed by the BERC

SL.	Particulars
A	1. Crude oil FOB rate (BDT per litre)
	2. Premium freight, service charges (BDT per litre)
	(A) Total Produce Cost[8]
B	Handling Commission (BDT per litre)
	Port Dues (BDT per litre)
	Survey Fee (BDT per litre)
	Insurance (BDT per litre)
	Bank Charge and Commission (BDT per litre)
	(B) Total Import-related Other Direct Expense
C	(A)+(B) Total Landed Cost (BDT per litre)
D	Total Storage and Supply Expense (BDT per litre)[9]
(i)	(C)+(D) Pre-tax Ex-Refinery Price (BDT per litre)
(ii)	VAT (15%)
(iii)	(i)+(ii) Post-tax Ex-Refinery Price (BDT per litre)
(iv)	VAT at the Business level
(v)	Fuel Oil Development Fund (BDT per litre)
(vi)	Internal Transportation Cost (BDT per litre)
(vii)	Storage and Marketing Expense
(viii)	Total Local Transportation Expense (BDT per litre)

(Table 10 contd.)

[8]Ocean Loss and Pipeline Distribution Expense are included in this segment, which are subject to incidence. In our case, we assume BDT 0 for both.

[9]Includes operational expense of BPC, expense associated with processing and refinery, technical loss.

(Table 10 contd.)

SL.	Particulars
	Other Expense, Technical Loss and Return
	(viii) Total Distribution/Dealers' Expense (BDT per litre)
E	(iii)+(iv)+(v)+(vi)+(vii)+(viii) Selling Price (BDT per litre)

Source: BERC.

Since the interim government of Bangladesh reinstated the BERC with the authority to set retail fuel oil prices (UNB, 2024), we would like to provide a brief overview of the automated fuel oil price formula proposed by BERC in 2023 (BERC, 2023). Notably, the BERC formula does not allocate a specific margin for any government bodies, including the BPC. In contrast to the BPC margin, BERC has allocated BDT 0.1 per litre for a fuel oil development fund, justified by the need for offshore exploration and infrastructure development. Aside from this adjustment, the remaining components of the BERC pricing formula are largely similar to those used by the BPC. One significant difference between the two price formulas is the taxation and tariff system. While the BPC has imposed multilayer tax and VATs, the BERC formula outlines only two kinds of VATs and no tax. The BERC formula has set a VAT of 15 per cent on the ex-refinery price of the fuel oil, whereas the VAT is only 5 per cent in the case of BPC formula. However, the main catch remains in the multi-layer VAT of the BPC. While the BERC only impose two VATs: one on the ex-refinery price of the fuel and a 2 per cent VAT on the traders, the BPC formula imposes a 5 per cent duty on the imported price of fuel oil, AIT of 2 per cent on the tariff value, VAT on L/C Commission, 15 per cent VAT on river dues, 15 per cent VAT on Ex-refinery price. Moreover, the BPC formula also sets out two development funds in addition to the BPC margin, financing, administrative, maintenance and development expense.

The major differences between the two formulas are summarised in Table 11.

Table 11: Major Differences between the BERC and BPC Formula

Issues	BPC Formula	BERC Formula
1. Pipeline transportation expense and ocean loss	The BPC formula sets a fixed rate for these expenses.	The BERC formula set the expense of these two components subject to incidence.
2. Administrative, maintenance and development expense of BPC	The BPC formula has set out an expense of BDT 1.065 per litre in addition to a BPC margin of 3% to 5% from the fuel oil price. [3% margin = 2.947; 5% margin = 4.912 per litre].	The BERC formula has set out less than BDT 1.18 per litre for BPC [BPC expense is included in the total storage and supply expense, equals BDT 1.18].
3. Tax, duty and VAT structure	Multilayer structure: AIT, a 5% duty on imported fuel, along with various additional VATs for maintenance, administrative costs, and development expense, at traders' point, VAT on ex-refinery price.	Simplified: VAT on ex-refinery price, VAT on traders' point.
4. Component with higher per litre operational expense	Internal transportation cost; financing charges (9% 3 months on crude oil); administrative, maintenance and development expense; allowable transit loss.	Total distribution and dealers' expense varies depending on the type of fuel oil; no allowable transit loss.

Source: Authors' Analysis Based on BERC and BPC Methodology.

6. CPD'S PROPOSED MARKET-BASED PRICING OF ENERGY FOR BANGLADESH

6.1 Conceptual Framework and Differences Between Administered and Market-based Pricing System

6.1.1 Context

The goal of this analysis is to predict and determine effective price of fuel oil at the import point by integrating international and domestic variables into a neural network model. We aim to predict the imported price of fuel oil using a model that integrates both international and domestic variables to reflect the comprehensive dynamics affecting the local fuel oil market. The aim of forecasting the fuel oil price in Bangladesh is to develop a neural network model that uses historical competitive (world) price data to predict domestic prices based on international price fluctuations. Historically, realised fuel oil prices in Bangladesh have primarily reflected the costs of importation, refining, and distribution, without adequately considering domestic demand, socio-economic conditions, or environmental factors (Raza, 2023; Islam, Ghosh, & Wang, 2023; Amin & Khan, 2020; Amin, Marsiliani, Renström, & Taghizadeh-Hesary , 2023). By building a model that first captures how international prices affect local prices, we can then integrate these forecasts with domestic variables to achieve more accurate and context-sensitive predictions for future prices. This approach allows for the determination of a suitable domestic fuel oil price that not only aligns with global market trends but also considers local economic realities, ensuring a competitive yet socially optimal pricing strategy. Historically, the overall socio-economic condition and purchasing power of Bangladesh has been improving over time. The Neural Network model captures these transitions to improved condition into account and determine a price that is consistent with the historical trend of improvement and do not allow for a deeper worse-off situation.

Since Bangladesh does not produce fuel oil domestically, it relies entirely on imports and only a part of refinery can be conducted in Bangladesh. Consequently, the price of fuel oil in Bangladesh is closely linked to international markets. The current pricing formula only takes into account the fluctuations of the international price of fuel oil, while other relevant factors are not considered in the model (MoPEMR, 2024). While it is true that Bangladesh imports all its fuel oil, the final price that consumers pay should not just be determined by international market prices. Several domestic factors, such as currency exchange rates, inflation, economic growth, and local demand, also influence the import price and the cost structure once the fuel oil reaches Bangladesh (Hosen, 2023; Islam M. A., 2013; Chowdhury & Dey, 2022). For example, even if the international price of fuel oil remains stable, a devaluation of the Bangladeshi Taka against the US Dollar would increase the cost of imports. Similarly, higher inflation can increase the cost of transportation and storage within Bangladesh, affecting the final price. Therefore, importers in Bangladesh must consider not only the international fuel oil prices but also local conditions like currency exchange rates, inflation, interest rates, and economic growth when determining import prices and strategies. In our analysis, we only consider the case of crude oil due to data availability.

True market pricing must account for both supply and demand complexities that impact economic reality and social welfare. However, we are not proposing a free market without a regulator. Rather, our proposed model facilitates a regulator regulating the market and setting the price in a way that would have been the case if the market were competitive. The model continuously adjusts for local socio-economic changes like exchange rate fluctuations and inflation to keep fuel prices relevant and fair for the consumers. The model considers optimal macroeconomic lags from historical long term non-linear time-trend and adjusts the effects accordingly.

6.1.2 Factors Determining Energy Price

In a competitive market, pricing is not simply a matter of adding supply costs to international prices. If that were the case, the market would resemble an automated but administered pricing mechanism - one that merely adjusts based on international benchmarks without reflecting the true local market dynamics. Such an approach fails to account for the complexities of supply and demand, potentially leading to prices that do not align with economic reality or social welfare. According to the supply and demand theory of economics, several exogenous factors can influence the selling price of a commodity in addition to the market demand (Kiran, 2022). These factors include but are not limited to exchange rates, inflation, interest rates, economic growth, and consumption patterns and ignoring these variables can lead to suboptimal pricing strategies that neither reflect the true cost conditions faced by importers nor address the demand dynamics within the country (Nagengast, Bursian, & Menz, 2021; Schill & Nixon, 2024). Hence, we plan to develop a pricing system which follows a competitive market feature that allows automatic adjustment of domestic fuel oil price in accordance with fluctuations in the international market.

We used the average price of fuel oil in our model to represent the price of fuel oil in Bangladesh because firstly, average price reflects the average cost scenarios, which is vital for planning and risk management. Secondly, the average price is a good benchmark to assess the competitiveness of fuel oil pricing in Bangladesh compared to international markets. Since the import prices must align with international peaks to secure adequate supply, using the average price ensures that the forecast considers the most probable scenarios. Lastly, understanding the average potential prices allows policymakers to anticipate and mitigate adverse economic impacts, ensuring energy security and affordability.

Our constructed model determines the effective price that should be charged within the domestic market. Besides, we also consider the fluctuations in the international market while adjusting the exchange rate, inflation rate, and other socio-economic factors to keep the price relevant for the Bangladeshi consumers.

6.1.3 Mathematical Formulation

Let's denote the forecasted price of fuel oil for year 't' as 'P_t'.

The forecasted price 'P_t' can be expressed as a function of both international market factors and domestic economic conditions:

(1) $$P_t=f(I_t,D_t)$$

where:

I_t represents the international market factors affecting the price in year '*t*'.

D_t represents the domestic socio-economic, demand and environmental conditions affecting the price in year '*t*'.

International crude oil prices are a primary driver of fuel oil prices globally. Since Bangladesh imports fuel oil, fluctuations in international crude oil prices directly impact the cost of crude oil imports. This variable serves as a baseline for understanding global market trends and their effect on Bangladesh's fuel oil prices and this variable serves as our target variables based on which we estimate the domestic effective fuel oil price.

In the case of international market factors, we mainly considered two variables: (a) world crude oil production and (b) world inflation rate. The production levels of crude oil globally affect supply dynamics and influencing international prices. Lower production levels may lead to higher prices, affecting Bangladesh's import costs. Global inflation impacts the costs of goods and services worldwide, including the costs associated with oil production and shipping. It also affects Bangladesh's import prices since Bangladesh represents the classic small economy assumption of classic macroeconomic texts.

In the case of domestic economic conditions, we incorporated exchange rate, domestic inflation rate, real interest rate, GDP growth rate, population growth rate, GDP per capita and estimated Gini index. First, the exchange rate between the Bangladeshi Taka and the US Dollar is critical because fuel oil transactions are typically conducted in USD. A weaker Bangladeshi Taka increases the cost of fuel oil imports, raising domestic prices. Second, inflation within Bangladesh affects the cost of transporting and distributing fuel oil once it is imported. Higher inflation can lead to increased costs across the supply chain, influencing the final price. Third, the cost of borrowing in Bangladesh, represented by the real interest rate, impacts financing costs for importers. Higher interest rates increase the cost of borrowing, making it more expensive for businesses to finance their operations. When borrowing becomes costly, businesses that rely on fuel oil as a key raw material—such as those in transportation, manufacturing, or power generation—may reduce their operations to manage costs, leading to a decline in the demand for fuel oil. This reduction in demand can, in turn, affect the pricing dynamics of fuel oil. Fourth, a measure of economic activity, GDP growth indicates potential demand for energy. Higher economic growth can increase demand for fuel oil, potentially pushing prices up if supply is constrained. Fifth, population growth influences fuel oil demand, particularly in sectors like transportation and energy. Higher demand due to population increases can drive up prices. Sixth, GDP per capita represents the average economic output per person, affecting purchasing power and, consequently, demand for fuel oil. Lastly, estimated Gini index measures income inequality, which can influence fuel consumption patterns. High inequality might reduce overall demand or shift consumption towards alternative energy sources.

Additionally, in the case of domestic consumption and production capacities, we include domestic fuel oil consumption and oil refinery capacity. Domestic fuel oil consumption represents the demand for fuel oil in Bangladesh. Understanding consumption trends helps forecast future price dynamics. Oil refinery capacity impacts the ability to process imported fuel oil. Higher capacity can reduce costs and reliance on external refining, potentially stabilising prices.

Finally, we incorporate growth rate of CO_2 emission from fuel oil which reflects environmental impacts and potential regulatory responses. Higher emissions might lead to stricter regulations, influencing fuel oil demand and price.

The framework acknowledges that international market dynamics set the baseline for fuel oil prices in Bangladesh. However, this transmission is modulated by domestic factors, including exchange rates, inflation, and economic growth, which influence the final import cost, and the price paid by consumers. Moreover, the framework includes mechanisms for adjusting predictions based on known future data points (e.g., the price for 2023), allowing for a recalibration of the model to improve accuracy and align forecasts with real-world observations.

6.2 Model Description

To forecast oil prices with enhanced accuracy, we developed a neural network using 'TensorFlow' and 'Keras' in Python. This process began with the collection of relevant data, including historical oil prices and various economic indicators, which we prepared to serve as inputs for our model.[10] The data was standardised[11], chosen for its robustness to outliers, ensuring that all features contributed equally to the model without bias.

Our model architecture is defined within a sequential framework provided by 'Keras'. The sequential model in 'Keras' is chosen for its simplicity and effectiveness in creating models where each layer has exactly one input tensor and one output tensor. This model type is ideal for a typical feedforward neural network. It includes several layers, each designed to process the data progressively to extract and learn complex patterns. This first dense layer has 64 neurons, a setting we initially chose based on our empirical understanding of the complexity of the dataset. Each neuron in this layer is fully connected to the input layer, and it uses the Rectified Linear Unit (ReLU) activation function. The ReLU is chosen for its ability to introduce nonlinearity into the model while mitigating the vanishing gradient problem, which is common in deep neural networks. Following the first dense layer, we included additional dense layers to deepen the model's capacity to learn from data. In the hyperparameter tuning phase, we varied the number of neurons in these layers (32, 64, 128) to find the optimal size.

To combat overfitting, we interspersed dropout layers with a dropout rate[12] initially set to 0.0, experimenting with rates of 0.2 and 0.5 in our hyperparameter tuning phase, finding that a moderate rate often provides the best balance between learning complex patterns and generalising well to new data. These layers randomly deactivate a set percentage of neuron connections during each training epoch, effectively simplifying the model temporarily and forcing other neurons to handle the 'missing' data, which strengthens the model's generalisation capabilities. The final layer in our neural network is a dense layer with a single neuron, using a linear activation function. This setup is typical for regression tasks where the goal is to predict a continuous value (Khalife, Cheng, & Basu, 2024) - in this case, the future price of oil. The linear activation function in the output layer is crucial as it allows the model

[10]The data description can be found in the next sub-section.

[11]We have used the 'RobustScaler' from scikit-learn for standardising the data.

[12] The dropout rate specifies the fraction of the input units to drop, helping prevent complex co-adaptations on training data.

to output a range of values that are not bound by a specific activation threshold, which is ideal for predicting prices (Murray, Abrol, & Tanner, 2022).

The model is compiled with the Adam optimiser, an adaptive learning rate method that adjusts itself based on the data it sees to minimise the loss function (Kingma & Ba, 2015), which in our case is the mean squared error (MSE).[13] This configuration helps in smoothing the learning process and in avoiding local minima in the loss landscape, which help converge faster and more effectively than the standard stochastic gradient descent.

We conducted a manual grid search to explore various combinations of neurons (32, 64, 128), dropout rates (0.0, 0.2, 0.5), learning rates (0.001, 0.01, 0.1), batch sizes (10, 20, 50), and numbers of epochs (100, 200). This extensive search was facilitated by K-fold cross-validation, specifically using 3 splits, to ensure that our model's performance was not only high but also stable across different subsets of the data. In other words, in each iteration, the model is trained on two-thirds of the data and validated on the remaining one-third. This process helps assess the model's performance metric, MSE, across different subsets of the dataset. This method also helped in identifying the best generalisable model settings that minimised validation loss. It ensures that the model is not overfitting to a particular subset of the data.

Once we had determined the optimal parameters for our neural network through the process of grid search and cross-validation, our next steps were to prepare the entire dataset for final model training and then to actually train the model using these best-found settings. Before retraining the model, we first needed to scale the entire training dataset. This step is critical because neural networks are particularly sensitive to the scale of input data. Different scales among features can lead to unequal initial weight contributions during the training process, which might impede the convergence of the optimiser. We adjust the data by removing the median and scaling the data according to the Interquartile Range (IQR):

$$X_{scaled} = \frac{(X - Q_1)}{(Q_1 - Q_3)} \qquad (2)$$

where Q1 and Q3 are the 25th and 75th percentile of the data, respectively.

We fit the scaler on the entire training dataset to learn the parameters and then transformed the data using these parameters. This ensures that all features contribute equally to the model's learning process, thus improving the model's ability to learn more effectively from the training data. Once the best parameters were identified - neurons set at 64, a dropout rate of 0.2, a learning rate of 0.01, 100 epochs, and a batch size of 10 - we proceeded to scale the entire training dataset and retrained the model on this transformed data.

To predict future oil prices, as mentioned before, we used a linear regression approach to project the future values of our input features for the years 2023 to 2025. The future features, which represent projected values of economic indicators and other relevant variables for upcoming years, was processed to match the scale of the data the model was trained on. This is critical because neural networks develop their predictions based on the specific distribution and scale of the input data they were

[13]MSE measures the average of the squares of the errors—i.e., the average squared difference between the estimated values and the actual value.

trained with. Any deviation in scale between the training and prediction phases can lead to significant inaccuracies. Then, we applied the aforementioned transformation [median and IQR, formulised in equation (1)], calculated from the training data, to scale the future features. This ensures that the scaling transformation remains consistent, preserving the relative distances and relationships among data points. Notably, when known future prices, such as the price for 2023, were available, we adjusted our predictions by an adjustment factor calculated as the ratio of the known price to the predicted price for 2023. This adjustment ensured our model's forecasts remained aligned with observed market trends, emphasising both the reliability and applicability of our predictive insights.

6.3 Data Description

Description of the data used in this study can be found in Table 12. The definition of the asterisk marked variables can be found in appendix A.

Table 12: Data description

Variable Name	Variable Description	Unit	Source	Year
er	Exchange Rate	BDT/USD	World Development Indicator	1977 to 2022
inf	Inflation Rate (GDP Deflator) - Domestic	% (2015 USD Constant)	World Development Indicator	1977 to 2022
rir	Real Interest Rate - Domestic	%	World Development Indicator	1977 to 2022
gdp_gr	GDP Growth Rate	% (2015 USD Constant)	World Development Indicator	1977 to 2022
oil_co2	Growth Rate of CO2 emission Oil Production and Consumption	%	Global Carbon Budget 2022	1977 to 2022
oil_r	Oil rents -	% (Total GDP)	World Development Indicator	1977 to 2021
pop_g	Population Growth Rate (Annual)	%	World Development Indicator	1977 to 2021
w_inf	World Inflation Rate (GDP Deflator)	%	World Development Indicator	1977 to 2021
gdp_pc	GDP Per Capita	current USD	World Development Indicator	1977 to 2021
cons_g	Total Final Consumption	petajoules, a unit of energy. One petajoule equals one quadrillion (10^15) joules.	World Energy Balances Highlights (2023 edition)	1971 to 2021
gini_mkt	Estimated Gini Index		Standardized World Income Inequality Database (SWIID)	1971 to 2022
oilpro_w	World Crude Oil Production	Thousand toe	OECD Data	1972 t0 2021
oil_cons_bar	Oil: Consumption	Thousand barrels daily	Statistical Review of World Energy	1971 to 2022
price_avg	Average Spot Price	USD per barrels	Statistical Review of World Energy	1972 to 2022
refiner	Oil Refinery Capacity	Thousand barrels daily		

Source: Authors' compilation.

6.4 Findings from the Empirical Model

The model achieved a MSE of 293.53, suggesting the average squared difference between the predicted oil prices and the actual prices in the test set. This value quantifies the variance in the predictions and indicates the model's precision in forecasting oil prices. Further, the model's effectiveness is underscored by an R-squared (R^2) value of 0.75. This statistic explains approximately 75 per cent of the variance in oil prices based on the model's inputs, highlighting a strong positive correlation between the predicted values and actual values. These findings demonstrate that the neural network has learned to predict oil prices with a high degree of accuracy, considering the complexity and volatility associated with energy markets. The relatively low MSE complements the high R^2 value, confirming the model's reliability and precision in practical scenarios.

The results, presented in table 13, include both adjusted and unadjusted predictions for the years 2023 to 2025. The higher predicted price for the unadjusted case is attributed to the higher crude oil price which was caused by the volatility in the international crude oil and energy market due to the Russian invasion on Ukraine. For adjusting this anomaly, we have changed the status quo value (price of fuel oil in 2022) for the price prediction by the observed value of 2023 fuel oil, which came down from the 2022 price within one year.

Table 13: Predicted Price of Crude Oil (Unadjusted and adjusted)

Issues	2023	2024	2025
Predicted Maximum Price (Unadjusted) – USD per barrel (BBL)	$130.90	$135.16	$139.42
Predicted Maximum Price (Adjusted) – USD per BBL	$88.80	$91.54	$94.29
Predicted Average Price (Unadjusted) – USD per BBL	$99.09	$102.19	$105.28
Predicted Average Price (Adjusted) – USD per BBL	$63.82	$65.81	$67.81
Predicted Average Price (Adjusted) – BDT per Litre[14]	BDT 43.09	BDT 47.60	BDT 49.04

Source: Authors' calculation.

The model initially predicted higher prices (unadjusted), but these were recalibrated based on known variables or additional insights to yield adjusted predictions[15],[16]. For example, the maximum price for 2023 was initially forecasted at approximately BDT 130.90 per litre but adjusted down to BDT 88.80 per

[14]In the case of the exchange rate, for 2023, USD 1 = BDT 107.36 has been utilised, whereas for 2024 and 2025, the exchange rate of July 2024, USD 1 = BDT 115 has been considered. Moreover, for the litre to BBL conversion rate: 159 litres = 1 Barrel has been considered (BPC, 2024). This is also the crude oil FOB rate, used in Table 4.

[15]The unadjusted predictions might represent a scenario without external interventions or market corrections, while the adjusted figures potentially account for known upcoming changes in market dynamics or policy influences that the model has integrated.

[16]The difference between the unadjusted and adjusted prices might also illustrate the model's sensitivity to certain input adjustments or reflect a deliberate calibration to align with more conservative or realistic market expectations.

litre, reflecting a significant recalibration based on updated information or model refinement strategies such as the application of an adjustment factor. Both the unadjusted and adjusted forecasts show a consistent yearly increase in oil prices. The adjusted predictions show a steady increment, rising from USD 88.8 in 2023 to USD 85.21 in 2025, which could reflect underlying economic, or market trends anticipated by the model.

6.5 Determining Retail Price of Fuel Oil Following BPC Formula

In this stage, we will determine the retail price of fuel oil for the years 2023, 2024, and 2025 using the automatic price adjustment formula established by the BPC. For this exercise, we will utilise the average price of crude fuel oil (Table 14). In the following exercise, we will compare the maximum potential retail price with the current retail fuel oil price in Bangladesh to explore opportunities for reducing prices.

Table 14: Retail Fuel Oil Price Determination (Part 1)

SL.	Particulars	Cost (2023)	Cost (2024)	Cost (2025)
A	1. Crude oil FOB rate (BDT per litre)	43.09	47.60	49.04
	2. Premium freight, service charges (BDT per litre)[17]	2.34	2.60	2.68
	(A) Total Produce Cost	45.43	50.20	51.73
B	Duty (BDT per litre): 5% for crude oil	43.09 x 0.05 = 2.155	2.380	2.452
	AIT (BDT per litre): 2% of tariff value	43.09 x 0.02 = 0.862	0.952	0.981
	(B) Total duty & taxes per litre in BDT	3.016	3.332	3.433
C	Handling Commission + Jetty Throughout Charge (BDT per Litre)[18]	0.006	0.006	0.006
	River Dues (BDT per litre) + 15% VAT[19]	0.029	0.029	0.029
	Survey Fee (BDT per litre)[20] - Standard Assumption:	0.0328	0.0328	0.0328
	Ocean Loss (BDT per litre) 0.5% on FOB for crude oil	0.215	0.238	0.245
	L/C Commission + VAT (BDT per litre)[21]	0.099	0.109	0.113

(Table 14 contd.)

[17]The figure for 2023 has been sourced from BPC Annual Report 2023. The cost is projected to increase in 2024 and 2025 based on the FOB price and cost of fuel oil sold.

[18]BDT 1 per BBL for Crude Oil (MoPEMR, 2024)

[19]BDT 34.10 per MT (MoPEMR, 2024) and 1 MT ≈1176.47 liters

[20]450 USD per vessel for independent surveyor + BDT 0.75 per MT for crude oil (MoPEMR, 2024) and standard conservative assumption of using medium size cargo ships (e.g., Bulk Carriers, Container Ships) for vessels. We assume a capacity of 1,500,000 litres container vessels. The cost will decrease if we assume larger ocean-going vessels (e.g., oil tankers, etc.).

[21]0.2% on FOB price for crude oil + 15% VAT (MoPEMR, 2024).

(Table 14 contd.)

SL.	Particulars	Cost (2023)	Cost (2024)	Cost (2025)
	Crude oil Processing Cost - Avg. Cost of ERL processing (BDT per litre)[22]	0.109	0.109	0.109
	Crude oil process lost[23]	0.0158	0.0170	0.0173
	(c) Total Operational Expense (BDT per litre)	0.581	0.622	0.636
C1	Average cost (A+B+C) incurred for fuel oil (BDT per litre)	49.026	54.153	55.798
C2	Cost (Tk per litre) considering balancing factor for HSD: C1*1.14	55.890	61.735	63.610
D	Financing charges (BDT per litre)[24]	15.513	17.135	17.656
	Administrative, maintenance & development expense (BDT per litre)[25]	1.065	1.065	1.065
	(D) Total financing, administrative, maintenance & development expense (BDT per litre)	16.578	18.20	18.721

Source: Authors' calculation.
Note: In part 2, the determination of the retail fuel oil price has been calculated by considering two BPC margin scenarios. The calculation and final price can be found in Table 11 and 12.

We would like to present two scenarios of BPC margin—one with the highest margin and other with the lowest margin in order to determine the retail fuel oil price in the second part of the retail price of fuel oil.

Table 15: Calculation of Retail Price of Fuel Oil (Part – 2): 3% BPC margin

BPC's Margin (3%)				
E	BPC's margin on C2+D (BDT per litre)	2.174	2.398	2.470
F1	Total cost: C2+D+E (BDT per litre)	74.643	82.333	84.801
F4[26]	3. VAT 15% on F1	11.20	12.35	12.72
G1	Ex-refinery price after VAT (F1+F4)	85.839	94.683	97.521
G	4. Company margin, development fund and freight pool (BDT per litre): BDT 0.8 + BDT 0.25 + BDT 1.20	2.25	2.25	2.25
	5. Dealer's commission and transport (BDT per litre)[27]	0.187	0.187	0.187

(Table 15 contd.)

[22]The average cost of processing has been derived from the ERL income statement and refining capacity which have been sourced from BPC Annual Report 2023.

[23]2.8% of all expenses except depot loss (MoPEMR, 2024).

[24]9% 3 months on FOB for crude oil (MoPEMR, 2024) and the amount has been converted to annual setting.

[25]Source: (MoPEMR, 2024).

[26]F2 and F3 are dropped from the original formula since our data consists only the crude fuel oil.

[27]The figure has been calculated using.

(Table 15 contd.)

BPC's Margin (3%)				
	6. Traders' 2% VAT on G1+4+5 (BDT per litre)	1.766	1.942	1.999
	(G) Total selling and distribution expenses (4+5+6)	4.203	4.379	4.436
H	Selling Price (BDT per litre): G1+G	90.04	99.06	101.96

Source: Authors' Calculation.

Table16: Calculation of Retail Price of Fuel Oil (Part – 2): 5% BPC margin

BPC's Margin (5%)				
E	BPC's margin: 5% on C2+D	3.623	3.997	4.117
F1	Total cost: C2+D+E (BDT per litre)	76.092	83.932	86.448
F4[28]	3. VAT 15% on F1	11.414	12.590	12.967
G1	Ex-refinery price after VAT (F1+F4)	87.506	96.522	99.415
G	4. Company margin, development fund and freight pool (BDT per litre): BDT 0.8 + BDT 0.25 + BDT 1.20	2.25	2.25	2.25
	5. Dealer's commission and transport (BDT per litre)	0.187	0.187	0.187
	6. Traders' 2% VAT on G1+4+5 (BDT per litre)	1.799	1.979	2.037
	(G) Total selling and distribution expenses (4+5+6)	4.236	4.416	4.474
H	Selling Price (BDT per litre): G1+G	91.74	100.94	103.89

Source: Authors' Calculation.

From the tables above (Table 15 and 16), it is evident that the retail prices derived from our model for the years 2023 and 2024 are lower than the retail prices set by the BPC as of June 2024 (Shishir, 2024). Notably, the derived retail prices still allow for a BPC margin of 3 per cent and 5 per cent, respectively, while also addressing socio-economic concerns. These prices incorporate demand, supply, and other exogenous factors, providing a comprehensive understanding of the market dynamics. This approach not only strengthens but also justifies the profit or surplus generated by the BPC, in addition to the margin established by the state-owned agency.

Furthermore, using a similar pricing approach, (MoPEMR, 2024) suggests adding a buffer of BDT 10/litre plus 15 per cent VAT on octane and diesel, as these fuels are predominantly used in private vehicles, categorising them as luxury items. However, the classification of these fuels as luxury items remains debatable. Additionally, adding a fixed charge of BDT 10/litre on retail fuel oil prices derived from crude oil products like HSD (High-Speed Diesel) does not catch up with the current pricing of petrol and octane and the current price of petrol and octane is much higher than the estimated price, suggesting a flawed algorithm in the existing pricing model of the BPC.

[28]F2 and F3 are dropped from the original formula since our data consists only the crude fuel oil.

The retail prices of petrol, octane and diesel, calculated in accordance with our proposed methodology and by considering 5 per cent BPC margin, are given in table 17:

Table 17: Retail Price of Various Types of Fuel Oil

Year	Petrol (BDT/Litre)	Octane (BDT/Litre)	Diesel (BDT/Litre)
2023	91.74 (BDT 1o9)	117 (BDT 130)	117 (BDT 127)
2024	100.94 (BDT 105)	127.58 (BDT 127)	127.58 (BDT 131)
2025	103.89	130.97	130.97

Source: Authors' Calculation.

The parenthesis indicates the actual retail fuel oil price of Bangladesh in 2023 and June 2024 (Vaidyanathan, 2022).

6.6 Determining Retail Price of Fuel Oil Following BERC Formula

Table 18 outlines the retail price of diesel generated from our neural network model, using the formula set out by the BERC, which is currently responsible for determining the retail fuel oil price. It is important to note that our analysis only covers the retail price of petrol due to the lack of sufficient data on the global price of diesel and octane over a long period. In the case of the formula set by the BPC, the prices of diesel and octane are determined based on the rationale that these fuels are luxury items, warranting a fixed proportion added to the retail price of petrol. However, the BERC's proposed pricing formula is based on the import FOB price of fuel oil. The concerns raised previously when calculating the retail price of fuel oil using the BPC formula still apply, as this approach remains heavily dependent on the face value of import prices, is affected by exchange rate volatility, lacks consideration of the broader economic conditions, and gives inadequate focus to demand-side factors.

Table 18: Retail Fuel Oil (Petrol) Price Following BERC Formula

SL.	Particulars	Cost (2023)	Cost (2024)	Cost (2025)
A	1. Crude oil FOB rate (BDT per litre)	43.09	47.60	49.04
	2. Premium freight, service charges (BDT per litre)[29]	7.20	7.56	7.94
	(A) Total Produce Cost	50.29	55.16	56.98
B	Handling Commission (BDT per litre)	0.02	0.02	0.02
	Port Dues (BDT per litre)[30]	0.0327	0.0353	0.0381
	Survey Fee (BDT per litre)	0.0011	0.0011	0.0011
	Insurance (BDT per litre)	0.0435	0.0435	0.0435

(Table 18 contd.)

[29]The figure for 2023 has been sourced from BPC Annual Report 2023. The cost is projected to increase in 2024 and 2025 based on the FOB price and cost of fuel oil sold.

[30]For the year 2024 and 2025, we have adjusted the expense with inflation rate of 8%.

(Table 18 contd.)

SL.	Particulars	Cost (2023)	Cost (2024)	Cost (2025)
	Bank Charge and Commission (BDT per Litre)	0.0373	0.0373	0.0373
	(B) Total Import Related Other Direct Expense	0.1346	0.1362	0.1380
C	(A)+(B) Total Landed Cost (BDT per litre)	50.43	55.30	57.12
D	Total Storage and Supply Expense (BDT per litre)27	0.9	0.97	1.05
(i)	(C)+(D) Pre-tax Ex-Refinery Price (BDT per litre)	51.33	56.27	58.17
(ii)	VAT (15%)	6.835	7.550	7.780
(iii)	(i)+(ii) Post-tax Ex-Refinery Price (BDT per litre)	53.30	58.86	60.69
(iv)	VAT at the Business level	1.066	1.177	1.214
(v)	Fuel Oil Development Fund (BDT per litre)	0.1	0.1	0.1
(vi)	Internal Transportation Cost (BDT per litre)	0.9	0.97	1.05
(vii)	Storage and Marketing Expense27	0.5	0.54	0.58
(viii)	Total Local Transportation Expense (BDT per litre)	0.8	0.86	0.93
	Other Expense, Technical Loss and Return	2.77	2.77	2.77
	(viii) Total Distribution/Dealers' Expense (BDT per litre)	3.57	3.63	3.7
E	(iii)+(iv)+(v)+(vi)+(vii)+(viii)			
	Retail Fuel Oil Price at the Consumer Level (BDT per litre)	65.14	71.10	73.51

Source: Authors' Calculation.

While comparing the retail price of petrol formulated by the BERC, we can observe that the retail petrol price of 2023 stands at BDT 80.95 per litre whereas if we use our proposed import effective price, we will see a price of BDT 65.14 per litre for petrol. The severe difference in price is largely attributed to the higher import FOB price of the petrol set by the BERC.

6.7 Implications of CPD Estimated Energy Price

In comparison to the import FOB price of fuel oil set out by the BERC and BPC, our calculation shows that the effective import price determined by our proposed model is closer to the import FOB set out by the BPC than that of the BERC. Therefore, our study strongly recommends the BERC to reconsider the rationale behind setting the import FOB price of fuel oil.

The study findings have several important implications for fuel pricing policy in Bangladesh. First, the analysis indicates that the current retail prices set by BPC could potentially be reduced while still maintaining an adequate profit margin. This suggests that there may be room for lowering prices to alleviate the financial burden on consumers, particularly in light of socio-economic factors. Second, by accounting for demand, supply, and other market conditions, our model provides a more market-driven approach to pricing, which is crucial for several reasons. A market-driven pricing strategy enhances transparency by reflecting the true cost dynamics and market forces that influence fuel prices. Unlike administered pricing mechanisms, which may only adjust prices based on international benchmarks or fixed margins, our model integrates a broader range of economic variables, allowing for more responsive and adaptive pricing decisions. This approach helps ensure that fuel prices are not arbitrarily set but are instead based on actual market conditions, promoting fairness in the pricing process.

Additionally, our pricing mechanism is designed to incorporate both the macroeconomic lag effect of currency fluctuations and the immediate impact of these fluctuations on the price of fuel oil. This is particularly important in a country like Bangladesh, where currency volatility can significantly affect import costs. By considering these effects, our model provides a more accurate adjustment to fuel prices, ensuring that any changes in currency value—whether gradual or sudden—are appropriately reflected in the retail price. This helps prevent abrupt price shocks and allows for smoother adjustments, minimising the financial strain on consumers.

Furthermore, our model investigates the non-linear relationships among various economic variables, such as exchange rates, inflation, and global oil prices. By capturing these complex interactions, the model enhances the accuracy of price adjustments, leading to a more stable pricing environment. This stability is critical in avoiding excessive financial constraints on consumers, especially in a volatile global economic landscape. By providing a more nuanced and comprehensive pricing framework, our approach supports better decision-making that balances market realities with consumer protection, ultimately contributing to a more sustainable economic environment. Finally, the findings challenge the current pricing strategy of treating certain fuels as luxury items, prompting a re-evaluation of the basis for such classifications and the associated price premiums. This could lead to more equitable pricing policies that better reflect the economic realities and consumption patterns in Bangladesh.

Lastly, according to our study, it can be observed that the market-based pricing system results in a lower and more realistic price compared to the administered pricing model, while still reflecting historical macroeconomic and market conditions. This confirms our hypothesis that a market-based pricing approach would lead to reduced prices because of the reduced purchasing power attributed to the vulnerable economy. By incorporating key variables such as exchange rates, inflation, and global oil prices, the model more accurately captures the true cost dynamics of fuel oil, offering a price that aligns closely with real market conditions. The price could be further reduced if the BPC margin were lowered and the multi-layered impositions of taxes, VAT, and other duties were more appropriately balanced.

6.8 Welfare Impacts, and the Green Transition: A Critical Assessment

The adoption of a market-based pricing system for fuel oil in Bangladesh, as indicated by our ANN-based model, suggests the potential for lower fuel prices while ensuring that households, businesses, and other consumers do not experience adverse economic shocks. Our model maintains welfare stability by mitigating the risks of abrupt price fluctuations, ensuring that any negative shocks remain controlled and do not disproportionately impact economic actors. However, while the model presents an opportunity for economic relief, particularly in an import-dependent fuel market like Bangladesh, its implications for the green transition raise concerns.

One of the core challenges associated with lower fuel prices is the potential deceleration of Bangladesh's green transition efforts. A decline in fuel prices could inadvertently incentivize increased consumption of fossil fuels, discouraging investment in renewable energy alternatives. Economic theory suggests that price elasticity plays a crucial role in energy consumption patterns—when fuel prices drop, consumers, including businesses and households, may increase their reliance on fuel oil instead of transitioning towards cleaner energy sources (Stern, 2008; Burke & Abayasekara, 2017). This phenomenon is commonly referred to as the 'rebound effect' (Gillingham, Rapson, & Wagner, 2016) where efficiency or price reductions lead to an overall increase in consumption, potentially counteracting sustainability goals.

To address this issue, our ANN-based pricing model incorporates CO_2 emissions from oil consumption as a key variable. This feature along with our threshold condition of non-negative change in welfare effects ensures that, while fuel prices may decrease, the model applies an upward pressure on price adjustments when emissions rise beyond a certain threshold. By doing so, the model inherently introduces a control mechanism to limit excessive increases in fuel consumption. However, it is important to acknowledge that while this mechanism can moderate short-term fluctuations, it may not be sufficient to fully counteract the long-term behavioural shifts toward greater fossil fuel dependence if structural incentives for renewable energy adoption remain weak.

Additionally, a lower price environment could lead to a surge in demand, particularly in a country like Bangladesh, where industrialisation and urbanisation are accelerating energy consumption (IEA, 2021). If the increase in demand surpasses manageable thresholds, the country may experience a reverse effect on its green transition trajectory, as higher fuel consumption could lead to delays in policy-driven shifts toward renewables. Nevertheless, this dynamic is also accounted for in our ANN model – higher demand exerts upward pressure on fuel prices, thereby naturally moderating excessive fuel consumption over time.

Our findings strongly suggest that the model will play a neutral role in the long run with respect to the green transition. Over time, market forces will adjust prices in response to increased demand, mitigating the risk of prolonged fossil fuel reliance. However, in the short run, there exists a significant risk that lower fuel prices could disincentivise the adoption of renewable energy solutions, thereby slowing the transition towards a greener energy mix.

6.9 Limitations of the Analysis

We employed time series yearly data for our analysis, which is appropriate for long-term forecasting. However, given that the price-setting authority typically adjusts and updates fuel prices at monthly or quarterly intervals, the model can still be adapted to suit this need. By incorporating quarterly or monthly macroeconomic data, which can be sourced from national internal agencies such as the Bangladesh Bureau of Statistics (BBS) or Bangladesh Bank reports, the model's predictions can be recalibrated for more frequent pricing updates. This flexibility ensures that the model remains relevant for setting fuel oil prices in a timely manner, while continuing to reflect both international price fluctuations and domestic economic conditions effectively.

The model integrates domestic and international factors but does not incorporate real-time adjustments for sudden macroeconomic shocks, such as currency crises or global oil supply disruptions. While the model accounts for currency fluctuations, it does not dynamically adjust for the lagging effects of these shocks, which might affect fuel oil prices over varying time horizons. This limitation makes it less suited for high-frequency or real-time forecasting. Hence, it would be required to update the dataset from time to time for this model to work effectively.

While we have included several key international and domestic factors, the model does not account for other critical variables, such as geopolitical risks, supply chain disruptions, or policy changes that could have a significant impact on the oil market. These variables are often difficult to quantify or forecast, but they play a crucial role in real-world price fluctuations. In that sense, it would be difficult to predict the future price fluctuations. However, accounting for those sudden factors in the model might improve the accuracy of the prediction. Nevertheless, the main goal of the Neural Network model is to set an effective international price for the country.

Policymakers and stakeholders should use the model in conjunction with qualitative assessments and expert judgment to ensure that fuel pricing strategies are both accurate and adaptable to changing conditions.

6.10 Placebo Test of the Model Using Time-Series Models

The study analysis revealed that time-series models are not well-suited for capturing the complex dynamics within our dataset, especially when contrasted with the flexibility offered by artificial neural networks (ANNs). To determine the feasibility of using time-series models, we performed a series of statistical tests that are foundational for effective time-series analysis, examining stationarity, seasonality, autocorrelation structures, and integration orders of the key variables. The results of these tests underscored significant limitations that compromised the reliability of traditional time-series modelling for the study data.

One of the first tests we conducted was the stationarity test, typically a prerequisite for time-series models, especially for autoregressive integrated moving average (ARIMA) and vector autoregressive (VAR) models. Stationarity implies that the statistical properties of the series—such as the mean, variance, and autocovariance—are constant over time. We used both the Augmented Dickey-Fuller (ADF) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests to gauge stationarity. However, results were mixed; some variables, such as retail prices, showed signs of stationarity after first-differencing, while others, such as global price indices and exchange rates, displayed non-stationary behaviour even after second-differencing, failing to satisfy the stationarity requirement. This inconsistency in stationarity across variables presented a significant obstacle, as time-series models generally require a stable set of variables to maintain model integrity.

In addition to stationarity, we examined the seasonal patterns within the dataset. Seasonality testing, including the use of autocorrelation functions (ACF) and seasonal decomposition techniques, revealed varying seasonal behaviours among the variables. Some variables exhibited strong annual seasonality, while others displayed semi-annual patterns, and a few exhibited no discernible seasonal pattern at all. This lack of uniformity in seasonal behaviour complicated the model selection process, as typical seasonal models like SARIMA assume consistent seasonality across the dataset. The variation in seasonal patterns, combined with the mixed results from stationarity testing, made it challenging to impose a cohesive seasonal structure across the dataset.

We also evaluated the integration orders of the variables to assess the possibility of using VAR models. Following detrending, we determined that the integration orders of the variables varied widely, from I(0) (indicating stationarity) to I(2) (requiring second-differencing to achieve stationarity). This variability in integration orders further hindered the potential application of VAR models, which assume a uniform integration level among all variables to ensure the validity of the cointegration framework. Mixed integration orders prevent the straightforward application of error correction models (ECM), as ECMs require variables to share a common integration order to detect long-term equilibrium relationships. Since the data did not meet this condition, pursuing VAR models with ECM would have led to a model with unstable long-term behaviour and questionable validity.

Time-series models are also particularly sensitive to time shocks, an issue that was evident in our dataset. External shocks, such as sudden economic or geopolitical events impacting fuel prices, led to abrupt shifts in some variables that time-series models struggle to accommodate without creating instability. For instance, exchange rates and global price indices showed sharp fluctuations during specific years, which disrupted the autocorrelation patterns and undermined the reliability of time-series-based forecasts. This vulnerability to time shocks raised additional concerns about the robustness of a time-series approach within a volatile market environment.

While certain variables passed individual tests, others did not, making it difficult to apply a consistent time-series model across the entire dataset. Some variables met the requirements for stationarity and seasonal coherence, but the majority did not, rendering a comprehensive time-series approach impractical. Recognising the limitations of traditional time-series models under these conditions, we determined that an ANN model, with its ability to handle non-linear relationships and mixed integration levels, would be a more effective approach. Unlike time-series models, ANNs do not impose strict assumptions regarding the stationarity, seasonality, or integration order of variables, which allows for more flexibility and adaptability in the presence of shocks and heterogeneous patterns.

Given the extensive testing we conducted on each variable, and the varied results across different statistical properties, we concluded that a time-series model would not provide a reliable or stable solution for the analysis. Although a detailed breakdown of the test results for each variable is beyond the scope of this paper, we will present these findings in the final report. These detailed results will further clarify our decision to favour an ANN-based approach, which better aligns with the complexities and data inconsistencies observed throughout our testing process.

7. INSTITUTIONAL FRAMEWORK OF BERC AS AN ADMINISTRATOR

As it is clear that the Bangladesh Energy Regulatory Commission (BERC) has a legislative act that allow BERC as an institute to determine, implement, monitor, evaluate and asses the whole automated fuel oil pricing mechanism. Methodology of the fuel oil pricing should be based on the BERC regulations, acts and rules as it is legally under BERC's jurisdiction. The BERC should be the sole both price determining and regulatory authority of fuel oil price. The regulation and price determination of LPG by the BERC has been considered as a standard process of setting the energy prices. The BERC has been suggested as the regulatory and implementing authority of the petroleum oil prices as well. As BERC has already prepared a draft regulation for the determination of fuel oil price, it is only the matter of time that the interim government will permit the BERC to act as an administrator of fuel oil market. The new methodology is distinct compared to the BPC one from several aspects. The main aspiration of the new BERC methodology is to ensure the consumers' affordability of the fuel oil price, hence enhance consumers' welfare.

Test year: The BERC methodology includes the concept of test year for the implementation of the tariff adjustment according to the new methodology. The reason is to assess and test the economic implication of the new tariff for the first 12 months. The commission will monitor and observe whether the tariff adjustment is justified or not based on the economic implications caused by the adjustment.

No confusing determinants have been included: There are other factors or variable mentioned in the formula which are mentioned clearly with proper explanation. The BERC formula refrained from including any dubious indicators or factors in the fuel oil pricing.

Not including any margin in the methodology: The biggest distinction is the BERC methodology does not include any separate factor of margin like the BPC. Rather, it includes the operational expenditure of the BPC in the formula. This is only justified because as a state-owned utility selling authority, the BPC should not keep any extra margin given the already existing operational expenditure of BPC.

TAX, VAT and AIT: The BERC methodology only includes a much lesser rate of VAT and tax, and it does not include the AIT (corporate tax). The state-owned companies do not need to pay corporate tax, whether in the form of AIT or not. However, the BPC methodology includes corporate tax as well.

In addition to the determination of the methodology the price of the fuel oils should be set by BERC. BERC can carry out the following activities as an administrator of the energy market.

Determining the price of the fuel oil: The BERC must play the role of the price determining authority for all type of fuel oil. The price must be determined based on the BERC methodology.

Regulating and monitoring the fuel oil price: The implementation of the determined fuel oil price and regular adjustment of the domestic price aligning with the international prices should also be closely monitored by the BERC.

Monitoring the fuel import by BPC: Monitoring of the BPC as an both importing and implementation authority has been questioned again and again. The BPC working as both importer and regulator questions the credibility of the system. Hence, BPC's responsibility will only be to import the oils and BERC should monitor the fuel import process and evaluate the costs accordingly.

Ensuring transparency in energy sector management, cost rationalisation and tariff determination through public hearings: The provision of public hearing is already proposed in the BERC regulation. Bi yearly public hearings on the automated fuel oil pricing and implementation will help ensure the transparency of the financial conditions of BPC oil distribution companies, while including the key beneficiaries such public in the pricing process.

Enforcement of fiscal discipline among the fuel oil companies: The BERC should hold the public energy companies, including the BPC, regarding their fiscal situation. Evaluating the financial and audit reports and holding the institutions accountable for their fiscal measures should also be the part of BERC's jurisdiction.

8. RECOMMENDATIONS

The new pricing formula adopted by the BPC and BERC are faulty and will fail to meet the broader economic, social and environmental targets desired to achieve through the automated pricing formula attributed to the scope of price reduction. The study develops an alternate price setting models and tests their possible applicability in the context of the energy market of Bangladesh; and proposes an appropriate price setting model for the fuel oil prices in Bangladesh from the energy security and energy transition point of view. Followings are the set of recommendations to be carried out by the MoPEMR, BPC and BERC.

Determination of Import FOB Price: Although the proportional cost of the BERC is smaller than those of the BPC formula, a concern regarding the pricing formula remains for both the BERC and BPC formula at the import FOB price of fuel oil, which is taken at the face value and vulnerable to the shock of exchange rates. Our model proposes a different effective price at the import point, more shock absorbing and hence, suitable to the current socio-economic context.

The current methodology of price determination must be reviewed based on the international best practices: The pricing methodology by the BPC has several variables, margins and indicators that are confusing and do not follow the international best practices. The methodology should follow the standard practices maintained by all the other pricing authorities. The import FOB price of the BERC formula needs to be revised and considering face value of the import cost will make the country vulnerable to the global shocks and adverse trends. The country needs more stable, market based – shock absorbing rationale for setting the fuel oil price.

Methodology of Retail Price Needs to be Redetermined: Based on the findings of the study, which presents a market-based pricing model using an Artificial Neural Network (ANN), it is strongly recommended that the current methodology of price determination be redetermined. The adoption of the ANN-based model, as outlined in the study, will not only simplify the pricing mechanism but also ensure that it is sensitive to both fiscal constraints and consumer capabilities. This change is essential for fostering a balanced and equitable pricing environment, aligning with international best practices and improving transparency and fairness in pricing strategies.

Predictive Pricing and Consumer Planning: The implementation of the ANN-based model at the importing stage has significant advantages for future price predictability. By accurately forecasting fuel prices, consumers can better form expectations about future costs, facilitating smoother consumption planning. This anticipatory pricing model allows households and businesses to budget more effectively, ensuring they are less vulnerable to sudden price fluctuations. Enhanced predictability not only contributes to improved energy security perceptions but also stabilises market prices.

Balanced Approach between Welfare and Energy Transition: In accordance with the discussion from section 6.8, we propose a balanced approach, where policymakers should complement market-based pricing with targeted interventions, such as carbon pricing mechanisms, renewable energy subsidies, and regulatory frameworks that prevent excessive reliance on fossil fuels while still allowing market efficiency to drive economic welfare.

The draft commission prepared by BERC for the fuel oil price should be approved by the ministry immediately: The draft mandate regarding the determination of fuel oil by the BERC must be approved by the ministry. This approval will allow authority to the BERC to determine the price of all the fuel oils.

BERC should be the regulatory authority for determination of all the fuel oil price: As the BERC has been established as a regulatory body of the power and energy sector, the full monitoring and implementation of the automated pricing model should be executed by BERC. The BERC can organise public hearings on a regular basis to ensure the transparency of the process.

Australia government should further look into the trade and investment in renewable and clean energy technologies: Australia has the resources and opportunities of investing in developing countries to expedite their renewable and clean energy including Bangladesh. Other development partners are also taking interest in renewable energy in Bangladesh. Australia can also partner and explore the ways to shift their FDIs from gas and petroleum to renewables.

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Appendix

Appendix A: Definition of selected variables

Variable	Variable description	Definition
oil_r	Oil rents	Oil rents are calculated by subtracting the total costs of production from the value of crude oil production at regional prices.
cons_g	Total final energy consumption	Total final consumption is calculated as the sum of energy consumption across all end-use sectors, excluding energy used for transformation processes and the energy producing industries' own use. It primarily reflects energy deliveries to consumers, although it does not account for stock changes. Additionally, backflows from the petrochemical industry, included in other supply sources and transformation in petrochemical plants, are excluded from final consumption. It is important to note that international aviation and marine bunkers are generally not considered in final consumption. However, for global totals, they are included and reported as world aviation and marine bunkers under transport.
gini_mkt	Estimated Gini index	This variable represents an estimate of the Gini index, which measures inequality in household market income (pre-tax, pre-transfer) on an equivalized scale (using the square root scale), utilizing data from the Luxembourg Income Study as the benchmark.
oil_cons_bar	Fuel oil consumption	Fuel oil consumption is calculated as the sum of inland demand, international aviation and marine bunkers, and refinery fuel and loss. It includes derivatives of coal and natural gas but excludes consumption of biogasoline (such as ethanol) and biodiesel.
price_avg	Average spot price	Average spot price for crude oil: Dubai, Brent, Nigerian Forcados, West Texas Intermediate
price_max	Maximum spot price	Maximum price of the four spot prices

Source: Authors' compilation.

The transition from an administered to a market-based fuel pricing system in Bangladesh, initiated in March 2024, marks a significant step towards reducing fiscal burdens and aligning domestic fuel prices with international markets. However, the existing pricing mechanisms formulated by the Bangladesh Petroleum Corporation (BPC) and the Bangladesh Energy Regulatory Commission (BERC) exhibit critical shortcomings. To address these deficiencies, this study proposes a pseudo-market-based pricing mechanism using an artificial neural network (ANN)-based predictive pricing model that integrates both international and domestic economic variables.

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