SCOPES FOR EARLY RETIREMENT OF COAL-BASED POWER PLANTS

What Strategies Can be Adopted?

Khondaker Golam Moazzem

Shiyan Sadik

সেন্টার ফর পলিসি ডায়লগ (সিপিডি)

Centre for Policy Dialogue (CPD)

SCOPES FOR EARLY RETIREMENT OF COAL-BASED POWER PLANTS

What Strategies Can be Adopted?

Khondaker Golam Moazzem
Shiyan Sadik

সেন্টার ফর পলিসি ডায়লগ (সিপিডি)
Centre for Policy Dialogue (CPD)

Publisher

Centre for Policy Dialogue (CPD)
House 40/C, Road 11 (new)
Dhanmondi, Dhaka-1209, Bangladesh
Telephone: (+88 02) 48118090, 55001185, 58156979
Fax: (+88 02) 48110414
E-mail: info@cpd.org.bd
Website: www.cpd.org.bd

First Published June 2023

Copyediting
HM Al Imran Khan

Page Layout and Typesetting
Md Shaiful Hassan

Citation: Moazzem, K. G., Sadik, S. (2023). *Scopes for Early Retirement of Coal-based Power Plants: What Strategies Can be Adopted?* Dhaka: Centre for Policy Dialogue (CPD).

Abstract

It is evident that coal has been detrimental to a sustainable future, and the Bangladesh government has decided to make a transition from coal to an alternative fuel source. However, the transition pathway from coal to an alternative is not without challenges. The early retirement of coal-based power plants is an option that has been researched at theoretical and empirical levels. This study focuses on the abandonment decision of a coal plant from the economic perspective and discusses the necessary guidelines that the government can adopt as long-term plan. Based on the data analyses and results on a domiestic coal power plant, it appears the decision of abandoning coal plants for the futuristic approach can be justified. It reveals that with the estimated value of the future cash flow, the financial investors can decide whether to abandon a project or sustain it. The adopted approach in the study for calculating the abandonment value based on different variables can be applied to other coal plants which are in operation in the country. Moreover, this framework can be used to apply to the coal power plants which are in the planning or under construction stages.

Acknowledgements

The study is authored by *Dr Khondaker Golam Moazzem*, Research Director, CPD and *Mr Shiyan Sadik*, Former Research Associate, CPD.

The authors like to express their sincere gratitude to government officials, private sector professionals, and representatives from Civil Society Organisation (CSO) and academia.

The research team gratefully acknowledges the valuable support received from *Dr Shah Md. Ahsan Habib*, Professor (Selection Grade), Bangladesh Institute of Bank Management, *Mr Avra Bhattacharjee*, Joint Director, Dialogue and Outreach, CPD, *Mr HM Al Imran Khan*, Publication Associate, CPD, and *Mr S M Khalid*, Dialogue Associate, CPD.

Contents

List of Tables and Figure

Acronyms

APSCL	Ashuganj Power Station Company Ltd
AV	Abandonment Value
BDT	Bangladeshi Taka
BGWED	Bangladesh Working Group on External Debt
BPDB	Bangladesh Power Development Board
CEE	Central and Eastern Europe
CO2	Carbon dioxide
CPGCBL	Coal Power Generation Company Bangladesh Limited
CRI	Climate Risk Index
EGCBL	Electricity Generation Company of Bangladesh Limited
EU	European Union
GW	Gigawatt
JTT	Just Transition Transaction
JVC	Joint Venture Company
LNG	Liquefied Natural Gas
MW	Megawatt
NPV	Net Present Value
OECD	Organisation for Economic Co-operation and Development
PPP	Public Private Partnership
PSMP	Power Sector Master Plan
RoE	Return on Equity
RPCL	Rural Power Company Limited
USD	US Dollars
WACC	Weighted Average Cost of Capital

SECTION 1

Introduction

The immense acceleration of industrialisation over the past decades has created a significant rise in demand for energy across the world. However, the extreme use of fossil fuel-based energy has gradually triggered the red alarm for the environment. The most depicted illustration of such use is the augmenting concentration of carbon dioxide (CO2) and several greenhouse gases eventually ending in a global temperature rise of around 1-5 degree Celsius over the last century (Wuebbles & Jain, 2001). This led the policymakers to entitle themselves with the idea of transitioning coal energy – a major source of fossil-fuel based energy to alternative options such as moving to clean energy.

Conceptually, clean energy denotes the idea of zero-emission, renewable sources of energy not polluting the climate with proper efficiency measures. Clean energy is mostly a blend of renewable and green energy. The advanced footsteps which were discussed and debated among the changemakers were a rapid scaling up of the transition from coal power to clean energy production, the end of construction for newly proposed coal power plants and an inclusive transition for workers and communities agreed upon by 44 countries (Climate Champions, 2021).

Now, Bangladesh is accounted for 0.56 per cent of the global emission in CO_2 but still has been facing drastic climate vulnerabilities. The Climate Risk Index 2021, which has been based on the data of the last two decades, substantially provides evidence in different indicators related to climate and eventually ranked as the seventh most environmentally vulnerable country in 2021 which is followed by the same rank in 2020 (CRI, 2021).

The government of Bangladesh has decided to move towards fewer coal-based projects by scrapping 10 coal-based power plants, worth 12 billion US Dollars (USD) of foreign investment, to maintain a sustainable energy mix. But this decision of abandoning 10 proposed coal plants is crucial in terms of the rising coal price in the existing volatile global energy market due to multifarious reasons. Currently, two major coal plants in Barapukuria and Payra are operational. As per the latest government decision, it has been evident that coal has been detrimental to a sustainable future. And the government has decided to make a transition from coal to an alternative. Several environment-based studies have been conducted based on Barapukiria and Payra that came up with important findings related to socio-economic, meteorological, and environmental outcomes based on environmental impact assessment (Alam, et al., 2011). However, certain transition-related concerns remained unaddressed.

Besides, the transition pathway from coal to an alternative has not been covered in the earlier studies. The early retirement of coal-based power plants is an option that has been researched at theoretical and empirical levels. To adopt an early retirement plan, it is required to incorporate an investment approach that will be including the abandonment value, internal rate of return, equity and loan repayment, regular operational maintenance cost, salvage value, and environmental cost which are not properly addressed in the previous literature. The amount of compensation or penalty packages for power plants with multiple stakeholders such as foreign investment, loan, and equity shares are not discussed in any of the literature, as well.

This study focuses on the abandonment decision of a coal plant from an economic perspective and discusses the necessary guidelines that the government can adopt for the future long-term plan.

SECTION 2

Analytical Framework of the Study

Based on the availability of natural resources, Bangladesh steadily transitioned from a coal-intensive system to a natural-gas-intensive module in the power and energy industry. However, according to the updated power system master plan 2016, 34 planned coal power plants and 14 privately held coal projects are still operational (BWGED, 2021). This has initiated the core concept of early retirement plans for the currently operational coal projects. However, considering the escalating coal price, the public decision to scrap 10 proposed coal plants along with the early retirement decision of such profitable projects is critical.

2.1 Causes of Early Retirement of a Project

Building projects, roads, industrial structures, bridges, factories, dams, power, and communication projects, and so on are examples of abandoned construction projects. The termination of a project hurts stakeholders and parties including the developer, contractor, consultant, and customers. As previously indicated, the impacts on these parties include negative connections, untrustworthiness, litigation, conciliation, and cash-flow issues. As a result, defining the true causes of project abandonment is critical so that its prevention might be discovered (Ahmed, et al., 2000).

Simultaneously, several factors can adversely affect the usual lifetime of a project. Based on studies (Yap, 2013; Doraisami, et. al., 2015), several reasons can be drawn (Table 1).

These reasons can affect the life of an investment in the pre-construction, construction, or even during the operational phase. Investors from an economic and profit marginal perspective can make the decision either to abandon a project based on this, or they can continue the procedure with a newly revised plan. External factors like climate change and environmental damage have been evident in the present context which is the primary driver behind this study.

2.2 Early Retirement for a Project-Models for Decision on Abandonment

When considering whether to continue or quit a project, a general rule is - predicted future revenue should be weighed against related costs. If the anticipated revenue exceeds the relevant cost, the project should be continued. However, qualitative variables play a significant role in deciding whether to continue or terminate a project. If a company abandons a project only for financial reasons, it may have a negative impact on the overall image of the business and dilute the corporate brand, as well. Corporate reputation and brand dilution cast negative impacts on performing businesses in the future.

Table 1: Factors Responsible for Early Retirement of an Investment Project

Categories	**Adverse causes**
Procurement related issues	1. Wrong estimation of pricing and risk allocation 2. Tender process and feasibility studies 3. Acquisition of a proper geographical site 4. Lack of dispute resolution method
Management related issues	1. Control factors 2. Red tape 3. Bureaucratic issues 4. Poor quality control and safety management 5. Inadequate planning and scheduling problem
Stakeholders' issue	1. Financial difficulties by owners and contractors 2. Delays in interim pays 3. Skill set issues 4. Industrial disruption 5. Lack of motivation
External factors	1. Adverse weather 2. Unexpected difficulty in the location or site 3. Less co-ordination from the affected communities 4. Government policies 5. Estimation of negative externalities from environment 6. Estimation of health hazards 7. Climate change

Source: Authors' compilation based on published literature.

Furthermore, abandoning a project of national importance or one that provided the business considerable prominence undermines staff pride and may have a severe dysfunctional effect. As a result, abandoning a project is a difficult option. Several models by different businesses have been adopted to make decisions about abandonment (Table 2).

Table 2: Selected Models of Abandonment of Investment Project

Models	Synopsis	Relevant Industry/Business
Traditional model (Real option theory)	Real options were offered as a supplement to the information supplied by an investment project's cash flow sequence. It utilises the NPV model in this research to assess the amount of operational flexibility given by a genuine choice. This is a critical component of investment projects since the knowledge offered by a genuine choice might change a company's strategy. In practice, it is commonly understood that the NPV is a static valuation approach that presupposes the fundamental circumstances of a project cannot be modified. In effect, a company's capacity to be proactive in responding to changes in the environment allows it to capitalise on some strategic possibilities and thereby raise the company's value (Rambaud & Perez, 2016).	Despite academic literature advising that it be utilised in project evaluation, the real option method is not generally employed in commercial practice. But in reality, it is often utilised exclusively by organisations dealing with very significant amounts of money, such as those delivering energy or healthcare, or those in the technological industry. Previous survey findings note the complexity of its implementation, as well as a lack of familiarity, as reasons for the seldom usage of real choices. Many managers regard the models used to compute the true option value as a 'black box', requiring a high level of knowledge to implement. As a result, they expect that any errors in usage will be difficult to discover (Horn, et al., 2015).
The binomial option pricing model	The technique entails reconstructing all conceivable future situations with their associated probability of occurrence. This analysis can be firstly done for alternatives to abandon that matured within a single time. The expression for options expiring within two periods is then deduced, and the matching expression for options expiring within n periods is produced (Rambaud & Perez, 2016).	Mostly production and manufacturing industries
General entry–exit–scrapping model	Based on an investment project that runs in a random environment and produces a payout rate that is a function of a stochastic economic indicator, such as the price or demand for the project's output commodity. The investment project may function in two modes: 'open' and 'closed' Transitioning from one operating mode to another is expensive and immediate, and it is the result of a series of decisions taken by the project's management. The drawing assumption is the project can be permanently abandoned at any moment and for a fixed cost (Zervos, et al., 2018).	Financial investments

(Table 2 contd.)

(Table 2 contd.)

Models	Synopsis	Relevant Industry/Business
Optimal investment under operational flexibility, risk aversion, and uncertainty	When market uncertainty arises and decision-makers become more risk-averse, the ability to cancel, amend, or postpone existing initiatives becomes more important. The influence of such operational flexibility, defined as the ability to suspend and restart the project at any moment, on optimum investment strategies and option prices can be investigated. The scenario when the decision maker is risk averse and can pause and restart a project at no cost is examined. Under these conditions, it has been investigated how risk aversion, operational flexibility, and uncertainty influence investment decisions. To begin, a theoretical framework for investing under uncertainty with risk aversion and operational flexibility is established to obtain optimum investment and operational thresholds. Second, it has been depicted how risk aversion combines with operational flexibility to influence optimum investment policy (Chronopoulus, et al., 2011).	Projects incorporating risk assessment.
Abandonment decision model	A project is useful if the present value of all future net cash flows exceeds its abandonment value; otherwise, the project is retired or sold before its useful life expires. Abandonment value is derived from a variety of sources, including (1) knowledge of the salvage or price given to the business upon the liquidation of the investment, and (2) the relationship between future revenue collections and the salvage value. The goal of this study is to include uncertainty in the decision-making process for determining the best moment to discontinue a project (Jarrett, 2007).	Regular investment firms
Multidimensional lattice method	Done based on a mean reverting process by calculating salvage value (Abadie, et al., 2010).	Coal fired projects in EU

Source: Authors' compilation based on published literature.

2.3 Early Retirement Plan for Coal Industries

In the scenario of moving towards an early retirement of coal plants, Maamoun et al (2022) found that the plants recommended for early retirement are 13 per cent more expensive and 40 per cent more population exposure to emissions compared to an average plant in India. This can be incorporated in the case of Bangladesh also. This study will be based on domestic coal power plant which has been considered to be a profitable venture and the government has to decide upon a proper retirement plan for it. This study aims to calculate the abandonment value to come up with a decision of continuing the project or stopping its operation. Several factors can be incorporated whilst making a proper and timely decision. Moreover, the scopes need to be carefully considered.

Based on several published literature, it can be concluded that the most pragmatic methodology is to calculate the net present value and abandonment value to make up the decision. The calculation of abandonment value can be derived from salvage value and liquidation value.

SECTION 3

Methodology

This study outlines the overall depiction of the present coal-based projects in Bangladesh and uses the framework of a domestic coal power plant to establish an abandonment decision method for the ongoing coal projects.

Both secondary and primary data are used to attain the objectives of the study. Published information helped develop the methodology to calculate the abandonment value based on the analytical framework (Section 2).

The study focuses on a firm-based approach based on the abandonment value with the optimum time of abandoning an ongoing project from the financial perspective. The study used the financial data set of domestic coal power plant to have an estimation using R-VH Analysis. A particular unit of domestic coal power plant is selected to gather necessary data.

The primary assumption of this study is that the decision of abandoning a domestic coal power plant is evident and decided.

The R-VH analysis further assumed as follows:

(1) A meaningful cost-of-capital rate does exist;
(2) There is no capital rationing;
(3) All projects, existing as well as proposed, have the same degree of risk; and
(4) A meaningful, unique internal rate of return exists.

It is also assumed that the abandonment values over time are known and in variants concerning the cash flow patterns, noting that when these assumptions are inappropriate, their approach can be modified by specifying probability distributions for the abandonment values. In addition, it is assumed that the goal of the firm in selecting projects and in subsequently deciding to hold or abandon them is to maximise the discounted present value of the firm (where the rate of discount is the cost-of-capital, k).

According to the abandonment decision rule proposed by Robichek and Van Horne, 'a project should be abandoned at that point in time when its abandonment value exceeds the net present value of the subsequent expected future cash flow discounted at the cost-of-capital rate' In specifying this decision rule, they say if AVτ > PVτ, then abandon the project, where AVτ is the abandonment value in year τ and PVτ is the value of future cash flows from the project discounted to the year τ. That is

$$PV_a = \sum_{t=\tau+1}^{n} \frac{EC_{t.\tau}}{(1+k)^{(t-\tau)}}$$

ECt·τ= expected cash flow in year t as of year τ, k = cost of capital to the firm n = life of the project Thus, under the R-VH rule, the decision to hold or liquidate is made in each year τ based on whether or not the present value of the expected cash flows from the project is greater than the abandonment value in year τ. This is based on the optimal timing of the abandonment decision. An abandonment decision rule must permit us to choose among three options: hold the project for the life of the project; abandon now; or hold now and abandon at a convenient time in the future before project's lifecycle ends. This latter option presents a whole spectrum of additional alternatives which necessitates that an optimal rule tells us when to abandon as well as whether to abandon. The rule does not tell 'abandon now' simply because it is profitable to do so now but rather it also considers the cases where it may be more profitable to wait and abandon in the future. This requires calculation of -

$$Max_{\tau+1 \le a \le n} PV_{\tau.a} \ where \ PV_{\tau.a} = \sum_{t=\tau+1}^{a} \frac{EC_{t.\tau}}{(1+k)^{(t-\tau)}} + \frac{AV_a}{(1+k)^{(a-\tau)}}$$

and where a is the period in which we consider abandonment. Thus, we select the largest from the set of composite present values given in equation 2, where these values reflect the discounted cash flows of each holding alternative combined with the discounted abandonment value at the end of each holding alternative respectively. The first step is to calculate the required rate of return/Weighted Average Cost of Capital using a WACC calculator, which takes into account several factors such as current level of equity, current level of debt, tax rate, and so on. This largest value is then compared with the current abandonment value based on the calculation of liquidation value with recoverable ratio. Hence, the decision rule is if

$$Max_{\tau+1an} PV_{\tau.a} < AV_{a=\tau}$$

then abandon the project, and if

$$Max_{\tau+1\leq a\leq n} PV_{\tau.a} AV_{a=\tau}$$

then continue to hold the project and abandon at the a = τ corresponding to

$$Max_a PV_{\tau * a}$$

It is suggested that the incorporation of this rule into the capital budgeting process will eliminate the suboptimality arising from the R-VH rule, and the use of this rule by financial managers (where conditions warrant it) will reduce the danger of their 'abandoning' a project at the wrong time.

3.1 Calculation of NPV

The basic formula of NPV is used to calculate based on the financial statement of a domestic coal power plant based on the base year of 2021 where the value is discounted from the expected cash flow.

$$NPV = \frac{R_t}{(1+i)^t}$$

Where, NPV= Net Present Value
R_t= Net cash flow at time t
i= Discount Rate
t= time of the cash flow

Based on the financial statement of 2017- 21, the data of revenue flow has been estimated until 2026 with the calculation of growth rate. So the assumed lifetime or period is considered 10 years based on this. To find the discount rate I, the global calculator Weighted Average Cost of Capital (WACC) is used.

$$WACC = \frac{E}{D+E}(r_e)\frac{D}{D+E}(r_d)(1-t)$$

Where, WACC= Weighted Average of Cost of Capital

E= Market Value of Equity
D= Market Value of Debt
r_e= Cost of Equity
r_d= Cost of Debt
t = Tax rate (corporate)

Based on the WACC Calculator, the value of I has been calculated as 10.77%. Thus, NPV has been calculated based on that.

3.2 Calculation of Abandonment Value

To calculate the abandonment value, the liquidation value is used with a recoverable ratio to find out the abandonment value. Liquidation value is counted based on the current assets and non-current assets with the difference of liabilities based on 2021 as it is considered to be the base year.

SECTION 4

Policy Approach for Early Coal Retirement Plan: Global Context

Literature from different dimensions have been analysed regarding the transition and reformation of coal-based energy supply. The necessity of energy transition is mostly formulated based on the lower carbon economy incorporating climate stability (Fouquet & Pearson, 2012). Environmentalists and climate changemakers have mostly advocated for abandoning further coal-based projects.

4.1 Global Policies for Abandoning Coal

Early retirement of fossil fuel-powered power generation facilities, particularly coal-fired facilities that have the highest CO_2 emission rates, is frequently included in scenarios for decarbonising the power sector (Table 3). Early retirement as part of the transition creates several issues, such as who should pay for any stranded assets, and whether more measures are required to increase retirement certainty, minimise systemic risk, and costs (Climate and Electricity Annual , 2011).

4.1.1 Case of North America

In the USA case, the decision that coal generator owners must make regarding retirement is then described in a theoretical model. The correlations

Table 3: Policies of Selected Countries for Coal Phase Out

Name of Country	Zone	Recommended Policies	Expected No-Coal Year
United Kingdom	Europe	1.No new coal without CCS	A long-term energy plan covering every sector and energy source
Netherlands	Europe	Court challenge policy	2030
Germany	Europe	1. Coal exit law 2. Powering past coal alliance	2030
Greece	Europe	No coal exit	2025
Chile	South America	No policy	2025
South Korea	East Asia	Energy transition plan 2021-2040	Debatable.
Australia	Oceania	Announced in October 2020 by the Energy Ministry a moratorium on permitting new coal-fired power projects	2034
Mexico	North America	Announced plans to stop building new coal fired power plants after 2023.	2030
Poland	Europe	Positive trend with the cancellation of 33GW since 2015.	2036
China	East Asia	NDC plan for no new coal plant	2030
Egypt	Africa	Climate action summit and announcement of no coal	2022
Russia	Asia	No new coal	2030
Brazil	South America	Lamu project	2050
Mongolia	East Asia	Major 5GW solar project	2065
Malaysia	East Asia		2040
The Philippines	East Asia		2035
Indonesia	East Asia		2060
Vietnam	East Asia		2040
Sri Lanka	South Asia		2030
Pakistan	South Asia		2030
Senegal	Sub Saharan Africa		2028
Kenya	Sub Saharan Africa		Debatable
Botswana	Sub Saharan Africa		Debatable

Source: Author's compilation.

in the model for retiring generators are quantified using retirements from the previous 10 years. According to our prediction, most of the coal generation capacity will be retired in the next five years, with the remaining 25% retiring over the course of the following 20 years. The potential of policy to influence retirement age is limited. The typical lifespan of a generator is increased by six years with an electricity subsidy of USD 20 per megawatt-hour. A USD 51 carbon fee per tonne moves retirement dates up by about two years. In each case, a small number of electrical generators continue to operate on the grid after our projection horizon (Davies, et al., 2022).

Another study, by Haggerty, et al., 2018, analyses a dataset of 12 planning papers created by and for local communities facing the closure of coal facilities using an assessment approach informed by economic geography and community planning expertise in the west of the US. The results show a range of levels of acceptance of the coal transition as well as the lack of efficient ways to deal with lost local revenues, lack of links between environmental quality and long-term economic resilience. Together, the plans show how disorganised, conflicting policy environments for transition planning at the local level can have harmful effects. The need for policy interventions to address concerns of equity and efficiency were highlighted in this process.

4.1.2 Case of European Union (EU)

The Energy Union and Climate Action initiative's governance structure (European Comission, 2018) requires member states to develop national energy and climate strategies. The anticipated national contributions for 2030 must be quantified to meet the EU's goals for energy efficiency and renewable energy. These plans will address how energy generation will look in the future as well as how long existing coal-fired power plants will last. In the EU, coal plants with a combined capacity of 14 GW were shut down between 2016 and 2017, and another 7 GW of coal plants are expected to be retired. A total of 39.6 GW of coal-fired power capacity, or 25% of the coal-fired power plants in use in the EU, are located in member states where national governments have declared plans to phase out coal. A total of 39.6 GW of coal-fired power capacity, or 25% of the coal-fired power plants in use in the EU, are located in member states where national governments have declared plans to phase out coal (Climate Action Tracker, 2017).

Although coal use is declining in Western Europe, the majority of the new Central and Eastern Europe (CEE) members, led by Poland, continue to use it. In contrast to Hungary and Slovakia, which have a limited reliance on coal and a realistic goal of phasing it out by 2030, Latvia and Lithuania are the exceptions in this regard because they are coal-free. In contrast, Estonia is eager to keep running its oil shale power plants, which have the highest carbon intensity in the entire EU. More than 90% of Estonia's CO2 emissions are produced by burning oil shale, which accounts for 98 per cent of the hazardous waste that Estonia generates per person, which is 35 times more than the EU average (OECD, 2017)

The UK and Canada launched the Powering Past Coal Alliance in November 2017, and as part of it, governments, regions, and several enterprises have agreed to phase out current traditional coal generation in accordance with the Paris Climate Agreement. This entails a commitment by the Organisation for Economic Co-operation and Development (OECD) and EU members to phase out coal by 2030, with the rest of the world following suit no later than 2050. A total of 14 EU members have joined the Alliance: Belgium, Denmark, Finland, France, Italy, Latvia, Liechtenstein, Luxembourg, the Netherlands, Portugal, Sweden, and the United Kingdom (Galgóczi, 2019).

4.1.3 Case of Africa

Providing accessible energy to meet the region's fast-rising electrical demand while minimising socio-environmental effects and carbon emissions is a difficult task for Southern Africa. To create the most affordable low-carbon electricity paths for Southern Africa, were merged open-source geospatial, hydrological, and electricity grid-investment models. By 2040, wind and solar technologies could supplant other electricity sources in the area if fuel prices and technological advancements continue in their current directions. In all cases, apart from those where inter-regional transmission is hindered, new coal capacity is not created. Furthermore, attempts to save freshwater are aided by the fact that despite the region's vast hydroelectric potential, about half of the projected hydropower capacity is not cost-competitive (Chowdhury, et al., 2022).

In the case of South Africa, the JTT (Just Transition Transaction) sponsor-country counterparties' long-term financial commitments enable an expanded and sustained investment programme in grid infrastructure and renewable energy sources. This serves as the foundation for South Africa's much-needed post-Covid green industrialisation and economic recovery. In exchange, South Africa provides the globe with a sizable and extremely affordable mitigation opportunity. The JTT presents a unique chance for the nation to unleash the potential of a wide range of stakeholders to collaborate in order to break through the current energy policy impasse and propel the nation onto an ambitious, Paris-aligned, socially equitable decarbonisation pathway (Steyn, et al., 2021).

When Senegal joined the PPCA in 2018, the year Zambia abandoned its Maamba project, leaving it without a coal pipeline, it pledged to not produce any new coal. As of right now, no more coal projects are being considered in the Democratic Republic of the Congo, Guinea, Ghana, and Namibia. This will help reduce emissions of greenhouse gases and air pollutants from coal-fired power plants.

4.1.4 Case of East Asia

To recommend necessary transition pathways, Tong et al., (2018) estimated the development of air pollutants and CO2 emissions, a unit-based emission projection model of coal-fired power plants. This model can be utilised in various future policy evaluations and emission estimates for coal-fired power plants. It is a comprehensive knowledge of emission reduction under the present and aggressive energy path plans for development from 2010 to 2030. When power plant fleet structures are optimised, CO2 and air pollutant emissions are significantly reduced and energy efficiency is increased (NR vs ER scenarios), it may have positive effects on both air quality and the climate. The end-of-pipe controls would lower air pollutant emission levels even more (BAU vs BAT scenarios). Although coal is regarded as a 'dirty energy', the power plan and advanced control technology encourage the efficient use of coal resources in the power sector to reduce air pollution emissions. However, widespread implementation of cutting-edge control technologies could lessen but not completely eliminate emissions of greenhouse gases and air pollutants in coal-fired power plants.

4.1.5 Case of Southeast Asia

Three Southeast Asian nations no longer have any kind of coal-based power plants in the pipeline. According to its Energy Transition Plan 2021–2040, which was unveiled in June 2021, Malaysia is the first 'no new coal' country in the region. The pre-construction pipeline in the Philippines has decreased by 65% since July 2020. With the Energy Ministry's announcement of a moratorium on the permitting of new coal-fired power plants in October 2020, the Malaysian government has made it clear that its past pursuit of coal is coming to an end. After 2023, Indonesia, which in 2015 accounted for 4% of the world's coal pipeline, will discontinue developing new coal-fired power plants. Analysis, however, indicates this pledge leaves out more than 100 new projects that have not yet been completed. In Vietnam, 19.4 GW of coal is now in the pipeline. Although it is still the third largest in the world, Vietnam has had a favourable trend since 2015 with the cancellation of 33GW. Thailand, Cambodia, and Laos - three neighbours in the region- have not yet formally indicated plan to terminate their coal pipelines (Littlecot, et al., 2021).

4.1.6 Case of South Asia

Based on the current scenario of India, future emissions from the proposed coal power plants would also exceed the country's climate commitment to reduce its 2005 emissions intensity by 33% to 35% by 2030, which, when combined with other countries' commitments, is insufficient to meet the international goal of keeping warming well below 2°C relative to the pre-industrial era (Shearer, et al., 2017).

According to an estimation of (Shrimali, 2020), it has been observed that how a major portion of current coal plant capacity is becoming uncompetitive. This is because realised solar (and wind) tariffs, which represent the average cost of power from new solar facilities, are lower than the variable cost of running existing coal power plants. As a first step, the calculation was done by the value provided by retiring a typical coal plant and replacing it with a solar facility. The value is generated not only by renewing the energy contract but also by refinancing the outstanding capital payments. In year five, a retirement might save 33.90% on energy expenditures; 31.57% in fixed costs, including 5.37% in debt and 74.4% in equity payments.

In the case of Pakistan, the coal fleet is quite new (less than five years old). This makes retirement more difficult. Most coal-fired power facilities have not yet paid off their loans, with anticipated debt payments ranging from USD 665 million to 1.2 billion for each Pakistani coal power plant. The coal-fired power plants are extremely profitable for the owners, with contractual agreements guaranteeing a Return on Equity (RoE) of 27 to 35 per cent. Also, Pakistan's coal-fired power stations were financed with national guarantees, which ensured that project sponsors were paid on schedule. The current coal-fired power stations are owed USD 1.4 billion by Pakistan's Central Power Purchasing Agency-Guarantee (CPPA-G) (Nedopil , et al., 2022).

4.2 Worldwide Challenges of Early Coal Retirement Plan

The economic consequences and challenges of an early coal retirement plan need to be estimated properly from an investment approach. Based on a forecasted model by (Kefford, et al., 2018) , it has been estimated that in the period up to 2060, the reduction in retirement age necessary to satisfy this scenario might result in USD 541 billion in stranded power plant assets in the US, EU, China, and India alone. In certain circumstances, coal plants built within the last five years must be decommissioned after only half of their stated working lifetime. A regional study revealed China and India bore the great bulk of the expenditures, exacerbating worries about energy access and affordability. Policy options for minimising this impact include burden-sharing for equitable mitigation, investment in CCS technology, and international financial compensation. However, limits in all routes underscore the need for deeper study of the implied obligation to compel early retirements, in this case.

Weller (2018) identified how strategic framings disregarded local interests, distorted the concerns, worsened local disempowerment, and allowed re-distributional cash to be diverted to places that were not directly impacted by the looming shutdown of coal-fired power plants. This process's apparent unfairness highlights the constraints of climate policy-related strategic problems, scale, and location framing.

The notion of carbon retirement plan has generated mostly negative feedback in the US as the findings highlighted the absence of effective strategies while addressing local revenues, and the lack of connectivity between environmental quality, and long-term economic resilience (Haggerty, et al., 2018).

One of the most negative implications was studied in China regarding the labour market perspective which denotes a discriminative policy measure towards the government-owned coal plants and privately owned projects. It denoted that the coal workers from the government coal projects were reallocated with new jobs or provided with retirement benefits. On the contrary, the private workers were simply laid off without any job assistance and adequate funding (Wang & Lo, 2022).

In the scenario of moving towards an early retirement of coal plants, Maamoun et al (2022) found out that the plants recommended for early retirement are 13 per cent more expensive and 40 per cent more population exposure to emissions compared to an average plant in India.

SECTION 5

Position on Early Retirement of Coal-based Power Plants in Bangladesh

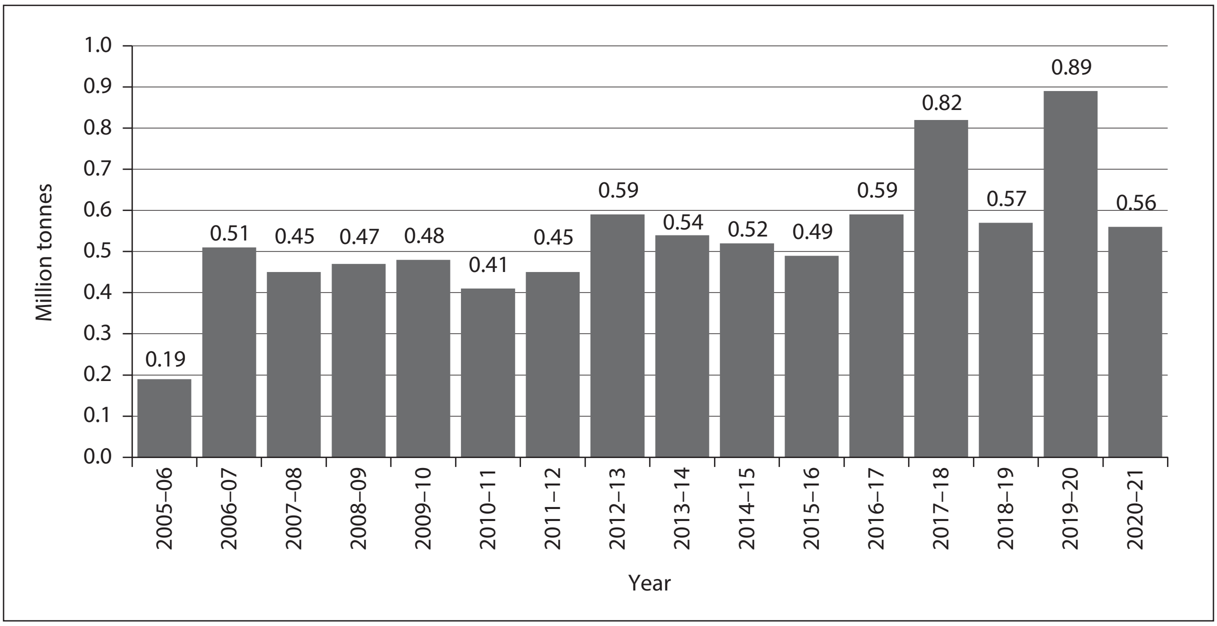
At present, Bangladesh is one of the world's largest hosts of coal power projects in the pipeline. The exploration of cheaper renewable energy- in the past several decades - allowed the world to shift from coal to power generation. If the 10 projects are cancelled based on the announcement, the country will be aligned with the global trend. Some of these coal projects were initiated a decade ago following the Power Sector Master Plan (PSMP) 2010 and were recently approved in the PSMP-2016 under a mixed energy policy. However, it has been evident to the government over the years that getting finance for coal power has become extremely difficult since major sponsors no longer support the 'dirty energy'. Instead, they support ecologically beneficial policies.

Adopting an early coal power plant retirement plan would include the scrapped decision of two coal-based power plants operating in Barapukuria and Payra. Most of the environment-based studies are done based on Barapukuria Coal Power Plant due to its length of operation. Although the coal from Barapukuria Coal Power Plant is of good quality, the mining procedures damage the air, water, and soil in the area, particularly in agricultural fields (Rashid, et al., 2014).

5.1 Present State of Coal Power Plants in Bangladesh

The government of Bangladesh has decided to move towards fewer coal-based projects by scrapping 10 coal-based power plants worth USD 12 billion of foreign investment to maintain a sustainable energy mix. But this decision to abandon the 10 proposed coal plants is crucial in terms of the rising coal price in the current global energy market context. From figure 1, the coal consumption pattern of the public sector of Bangladesh can be depicted for the last 16 years. Bangladesh experienced a sharp inclination in the year 2006-07 as the coal consumption rose from 0.19 to 0.51 which was further experienced by a continuous range between 0.4 to 0.6 till 2017. The consumption accelerated in the fiscal year 2017-18 as it rose to 0.82 and made the highest peak in the fiscal year 2019-20 to 0.89. Then it went back to the stagnant position of 0.56 in the last fiscal year.

Figure 1: Coal Consumption by Public sector (Year Wise) *(Million Tonne)*



Source: Petrobangla.

The price of coal rose from USD 6o to more than double between 2006 to 2013 (Table 4). It was initially USD 60 in 2006 but several increments are observed to reach the peak of USD 130.

Table 4: Unit price of Coal *(in USD)*

Date	Unit Price of Coal
26.06.06	60
02.04.08	60
01.07.08	71.5
27.10.08	71.5
23.12.08	71.5
13.01.09	71.5
15.03.09	71.5
01.08.09	71.5
01.07.10	86
05.05.11	86
01.01.12	86
01.02.12	105
04.01.13	105
01.05.15	130
24.05.16	130
01.03.17	130
01.06.17	130
01.06.19	130

Source: BWGED, 2021.

In the report of BWGED, the government intended to build 34 coal-fired power plants between 2018 and 2038, according to the Revised Power Sector Master Plan 2018 (PSMP 2018). It was reiterated in the Perspective Plan 2021–2041 (PP2041) but it placed more of an emphasis on (i) least-cost power generation (ii) low-cost primary energy (iii), infrastructure (iv), investment balance, (v) and energy efficiency (along with other targets). When PSMP 2016 was being developed, several domestic and international corporations suggested 14 undesirable coal power stations, and the Cabinet Committee approved 12 of them. It should be noted that none of the 14 unasked-for private bids managed to demonstrate appreciable progress toward building coal power plants by 2020. However, to develop 18 of the 34 coal power plants, the government negotiated both non-binding and binding agreements with various public and private entities.

To move on with the coal power project in Moheshkhali, the CHDHK was unable to obtain the requisite approval from the Chinese government according to several compilations of the BWGED. By abandoning the Sonadia Deep Sea Port project, the government has, in the interim, changed Moheshkhali Island's designation from Industrial Hub to Tourism Hub.

To perform a feasibility study on a Liquefied Natural Gas (LNG)-based power plant at the same location as a coal power project in Gazaria, Munshiganj, the RPCL and Marubeni Corporation inked a contract in September 2018. In March 2020, it decided to cancel the coal power project with Power China and HYPEC, despite the disappointment of its Chinese contemporaries.

June 2021 has been set as the new extended COD for the Patuakhali (APSCL) coal power plant. Although the sponsor firm has acquired the site and built it, it has not yet established the joint venture company (JVC) or obtained funding for the undertaking. The APSCL Annual Report 2019–2020 shows virtually little improvement.

Both CPGCBL-Sumitomo and CPGCBL-Sembcorp have acquired land, and construction of a landfill was visible on the Sembcorp site as of January 2021. However, the projects still need to get JVC and credit. According to its Annual Report 2019–2020, Bangladeshi sponsor CPGCBL appears to be quite optimistic about the projects, although Sumitomo and Sembcorp made no mention of them in their most recent annual reports (Table 5 and 6).

Table 5: An Overall Depiction of Planned Coal Plants in Bangladesh

Name	Location	Ownership	Capacity (MW)	Annual Fuel Requirement (mln Tonnes)	Budget ($- mln)	Lifetime (Year)	Expected COD
Adani Godda (Jharkhand) Coal Power Plant	Jharkhand	Private	1600	8	1,978	25	2022
Banshkhali S. Alam Coal Power Plant (Phase-I)	Chattogram	Private	1320	4.2	2,510.2	30	2022
Banshkhali S. Alam Coal Power Plant (Phase-II)	Chattogram	Private	1320	4.2	2,510.2	30	2022
Barapukuria Coal Power Plant (Unit III)	Dinajpur	Public	525	Undisclosed	332.31	30	2018
Barisal BEPCL Coal Power Plant	Borguna	Private	350	1.36	557.89	25	2022
CPGCBL-Sumitomo Coal Power Plant	Cox's Bazar	Private	1200	Undisclosed	Undisclosed	30	2026
Dhaka (Gazaria) Orion Coal Power Plant	Dhaka	Private	700	Undisclosed	Undisclosed	25	2022
Dighipara NWPGCL Coal Power Plant	Dinajpur	Private	1000	Undisclosed	Undisclosed	25	2032
Gazaria RPCL Coal Power Plant 9	Munshiganj	Private	435	Undisclosed	Undisclosed	30	2021
Kohelia (CPGCBL-Sembcorp) Power Plant (Phase-I)	Cox's Bazar	Public-Private Partnership (PPP)	1400	2.8	Undisclosed	25	2023
Kohelia (CPGCBL-Sembcorp) Power Plant (Phase-II)	Cox's Bazar	Public-Private Partnership (PPP)	1400	2.8	Undisclosed	25	2032
Maheshkhali BPDB Coal Power Plant (Phase-I)	Cox's Bazar	Public	1000	undisclosed	undisclosed	25	2036
Maheshkhali BPDB Coal Power Plant (Phase-II)	Cox's Bazar	Public	1000	undisclosed	undisclosed	25	2038
Maheshkhali BPDB-CHDHK Coal Power Plant	Cox's Bazar	Public-Private Partnership (PPP)	1200	undisclosed	undisclosed	30	2027

(Table 5 contd.)

(Table 5 contd.)

Name	Location	Ownership	Capacity (MW)	Annual Fuel Requirement (mln Tonnes)	Budget ($- mln)	Lifetime (Year)	Expected COD
Maheshkhali BPDB-KEPCO Coal Power Plant	Cox's Bazar	PPP	1200	undisclosed	Undisclosed	30	2029
Maheshkhali BPDB-PCC Coal Power Plant	Cox's Bazar	PPP	1200	undisclosed	Undisclosed	30	2024
Maheshkhali BPDB-SEPCO Coal Power Plant	Cox's Bazar	PPP	1200	undisclosed	Undisclosed	30	2028
Maheshkhali BPDB-TNB Coal Power Plant	Cox's Bazar	PPP	1200	Undisclosed	Undisclosed	30	2027
Maheshkhali BR PowerGen Coal Power Plant	Cox's Bazar	PPP	1320	Undisclosed	Undisclosed	30	2026
Maowa Orion Coal Power Plant	Munshiganj	Private	600	Undisclosed	Undisclosed	25	2022
Matarbari CPGCBL Coal Power Plant (Phase-I)	Cox's Bazar	undisclosed	1200	Undisclosed	Undisclosed	25	2023
Matarbari CPGCBL Coal Power Plant (Phase-II)	Cox's Bazar	undisclosed	1200	undisclosed	undisclosed	25	2028
Munshiganj EGCBL Coal Power Plant (Phase-I)	Munshiganj	undisclosed	435	undisclosed	undisclosed	25	2026
Munshiganj EGCBL Coal Power Plant (Phase-II)	Munshiganj	undisclosed	435	undisclosed	undisclosed	25	2029
North-Bengal APSCL Gaibandha Power Plant	Gaibandha	Private	1320	undisclosed	undisclosed	30	2031
Patuakhali APSCL Coal Power Plant (Phase-I0	Patuakhali	Private	1320	undisclosed	undisclosed	25	2024
Patuakhali APSCL Coal Power Plant (Phase-II)	Patuakhali	Private	1320	undisclosed	undisclosed	25	2031

(Table 5 contd.)

(Table 5 contd.)

Name	Location	Ownership	Capacity (MW)	Annual Fuel Requirement (mln Tonnes)	Budget ($- mln)	Lifetime (Year)	Expected COD
Patuakhali RNPL Coal Power Plant (Phase-I)	Patuakhali	PPP	1320	4.48	2,140	25	2023
Patuakhali RNPL Coal Power Plant (Phase-II)	Patuakhali	PPP	1320	4.48	2140	25	2031
Payra BCPCL Coal Power Plant (Phase-I)	Patuakhali	PPP	1320	4.12	1600	Undisclosed	2019
Payra BCPCL Coal Power Plant (Phase-II)	Patuakhali	PPP	1320	4.12	1600	Undisclosed	2023
Pekua EGCBL-Mitsui Coal Power Plant (Phase-I)	Cox's Bazar	Private	1200	Undisclosed	Undisclosed	Undisclosed	2025
Pekua EGCBL-Mitsui Coal Power Plant (Phase-Ii)	Cox's Bazar	private	1200	Undisclosed	Undisclosed	Undisclosed	2030
Rampal BIFPCL Coal Power Plant	Khulna	Undisclosed	1320	Undisclosed	Undisclosed	25	2021

Source: BWGED, 2021.

Table 6: List of Shelved or Cancelled Power Plants

Name	Location	Capacity	Expected COD
Banshkhali Beximco 660 MW Coal Power Plant	Chattogram	660	NA
Boalkhali Beximco Coal Power Plant	Chattogram	600	NA
Chittagong Orion 300 MW Coal Power Plant	Chattogram	300	NA
Gazaria RPCL Coal Power Plant	Dhaka	435	NA
Khulna South Orion Coal Power Plant	Khulna	660	NA
Maheshkhali BPDB-KEPCO Coal Power Plant	Cox's Bazar	1200	NA
Maheshkhali BPDB-TNB Coal Power Plant	Cox's Bazar	1200	NA
Maowa Orion Coal Power Plant	Munshiganj	600	2022
Mirsarai BSRM 300 MW Coal Power Plant	Chattogram	270	NA
Munshiganj EGCBL Coal Power Plant (Phase-I)	Munshiganj	435	2026
Munshiganj EGCBL Coal Power Plant (Phase-Ii)	Munshiganj	435	2029
Pekua EGCBL-Mitsui Coal Power Plant (Phase-I)	Cox's Bazar	1200	2025
Pekua EGCBL-Mitsui Coal Power Plant (Phase-II)	Cox's bazar	1200	2030

Source: BWGED, 2021.

SECTION 6

Results and Findings

6.1 NPV Calculation Outcome

The dataset has been used from the annual report of 2017–21 of a domestic coal mining. The initial step is to calculate the required rate of return/Weighted Average of Cost of Capital based on WACC calculator which includes several components such as current level of equity, current level of debt tax rate, among others. Based on the calculation, the rate of return is 11.07%. Then the sales revenue figures drawn from Income Statements for five years (i.e. 2017 to 2021), and the growth rate of each year are identified. After that, the average growth rate of those five years is identified (i.e. -0.3), and the estimated sales revenue for the next five years (i.e. 2022 to 2026) is calculated. Following that the discount factor for the period between 2022 to 2026 is estimated through discounting formulae. Subsequently, the estimated sales revenue of each year (2022 to 2026) is discounted with the discount factor to get the expected future cash flow. Lastly, the initial capital or investment from the sum of all expected future cash flows is deducted to get the NPV which is BDT 6,496,502,301.5 (Table 7).

6.2 Abandonment Calculation Outcome

Based on the liquidation value, which is a representative value of abandonment, the calculation is based on the recoverable ratio of total assets and liabilities. The abandonment value of 2021 is BDT 10,721,583,384.55 (Table 8).

Table 7: NPV Calculation of a Domestic Coal Power Plant

Required Rate of Return/WACC:								11.01%	11.01%	11.01%	1101%	11.01%
Financial Year		2017	2018	2019	2020	2021	Average Growth Rate	2022 (Estimated)	2023 (Estimated)	2024 (Estimated)	2025 (Estimated)	2026 (Estimated)
Time	0	1	2	3	4	5		1	2	3	4	5
Revenue Flow	(21,423,410,574.01)	10,228,960,006.0	12,481,812,067.0	9,079,575,417.0	8,907,687,490	8,319,931,904.0		8,034,459,982.40	7,758,783, 119.24	7,492,565,228.10	7,235,481,754.6	6,987,219,280.40
Growth Rate			0.22	-0.27	-0.02	-0.07	-0.03					
Discount Factor	1							0.9	0.81	0.73	0.66	0.59
Present Value	-21,4234 10,574.00							7,237,600,200.4	6,296,067,956.49	5,477,0 18,709.9	4,764,518,768.9	4,144,707,239.7
NPV	6,496,502,302											

Source: Authors' Calculation.

Table 8: Balanace sheet of a Domestic Coal Power Plant

Balance Sheet As at 30th June 2021				
Assets:				
Non-current assets		**2021**	**Recoverable Ratio**	**Recovery Value**
	Property Plant & Equipment	8,910,672,164.00	0.5	4,455,336,082.00
	Construction work in progress	21,825,994.00	0.5	10,912,997.00
	Un-Installed Capital Investment equipment	322,524,655.00	0.5	161,262,327.50
	Uninstalled Plant & Equipment	66,828,318.00	0.5	33,414,159.00
	Preoperating expenses		0.5	
	Own Finance Project	2,610,876,847.00	0.5	1,305,438,423.50
	Depreciation fund investment	7,242,137,635.00	0.5	3,621,068,817.50
Total Non-Current Assets		19,174,865,613.00		9,587,432,806.50
Current Assets:				
	Inventories	425,231,247.00	0.90	382,708,122.30
	Trade Receivable	3,301,819,059.00	0.75	2,476,364,294.25
	Advances, Deposit & Prepayment	74,695,713.00	0.00	-
	Investment in fixed deposit	3,373,354,286.00	1.00	3,373,354,286.00
	Inter-company current account	8,009,147.00	0.75	6,006,860.25
	Loan to employees	226,291,325.00	0.25	56,572,831.25
	Cash equivalent	607,657,807.00	1.00	607,657,807.00
Total Non-Current Assets		8,017,058,584.00		6,902,664,201.05
Total Assets		27,191,924,197.00		16,490,097,007.55
Total Liabilities		5,768,513,623.00		5,768,513,623.00
Net Liquidation Value		21,423,410,574.00		10,721,583,384.55

Source: Anecdote Source.

6.3 Final Output

The final output implements a higher value of abandonment than the net present value of 2021 which derives from the idea of abandoning the project for domestic coal plant (Table 9).

Table 9: Estimated Abandonment Value

Items	Value (BDT)
Net Present Value (NPV)	6,496,502,301.50
Net Liquidation Value/ Abandonment Value	10,721,583,385.00

Source: Authors' Calculation.

6.4 Discussion

As per the scenario, a project can be abandoned when the abandonment value is higher than the net present value. A project can plan for a break if there is a minimal difference between the value of both variables. If the NPV is higher than the abandonment value, then it can have continuous progress. Thus, from the results, three conclusions can be drawn for the domestic coal selected power plant-

1. As the abandonment value is way higher than the NPV for 2021, it can be inferred that the project can be abandoned at any time from now on.
2. As the difference is higher, the project should not go for a break and wait for the policies of the government to change. As a result, the second decision rule of waiting for the policies to change will be redundant.
3. As the NPV is lesser than AV. The project cannot be continued from a business perspective.

Based on the results of the selected domestic coal plant, it can be stated that the decision of abandoning coal plants for the futuristic approach can be justified. This formula of calculating the abandonment value based on different variables can be applied to other coal plants which are in operation. It might differ based on the financial activity and structure of each power plant but overall, the calculation of abandonment value based on the NPV can be an easily formulated decision making thumb rule. Moreover, this framework can be used to apply to the coal power plants which are in the planning or under construction stages. With the estimated value of the future cash flow, the financial investors can decide upon to abandon a project or not.

As each asset's recovery ratio is used to determine the abandonment value, the value will also consider the total sum that can be used as a compensation package for publicly owned projects. Here, the abandonment value amount worth BDT 10,721,583,385 can be referred to as the compensation package. However, this method of calculating the net present value can be applied to other privately owned ventures. As a result, the compensation package can include the net present value along with some other benefits. To be used as part of a compensation package to end the project earlier than expected, net present values represent the expected value discounted in the present. Moreover, the net environmental costs can be incorporated for further research in the formula which is not added here to draw a better picture of the decision.

SECTION 7

Way Forward

The quick phase-out of coal-based power plants in the local energy grid is an essential near-term approach for addressing global climate change. This includes current coal-fired power plants retiring at a quicker rate, which will be increased further if new projects in the planning stage are decided to be scrapped. Decommissioning coal-fired power facilities are critical to meeting the goals of the Paris Climate Agreement for Bangladesh. The government of Bangladesh needs to address several aspects while adopting an early coal retirement policy. As Bangladesh has been coal intensive, the changes are evident and need to be formulated on a long-term basis. From this study, several policies and strategies can be drawn up as a transitional pathway shifting from coal to any suitable source of alternative power generation.

Based on the present scenario, Bangladesh has decided to scrap coal power plants and slowly moving towards LNG and renewable energy as a reliable alternative. Based on this study, the decision of scrapping the domestic coal power plant comes up with the condition of having enough alternative supply of energy. As it is a major supplier in the national grid, it is necessary to adopt the alternative before phasing out this mega project. This applies to the other operational coal power plant in Payra to distinguish the necessary alternative supply source. Every planned coal-based power plant has been estimated to produce a significant MW for which the alternative should be addressed before taking the decision. Otherwise, this will disrupt the overall power generation supply chain.

From an investment perspective, financial investment has been endorsed for the domestic coal power plant. This project has a target of reaching its break-even point to further maximise the profit margin. A decision to scrap it will not be an economically viable decision if the early retirement compensation is not reimbursed to the relevant stakeholders. The study proposed to introduce early retirement compensation for other privately owned and joint venture power plants. The domestic one is a state-owned venture, it is necessary to provide a compensation package based on abandonment value calculation.

As abandonment value is calculated based on the recovery ratio for each asset, the value will incorporate the combined amount that can be used as a compensation package. But for the other privately owned ventures, this model of calculating the NPV can be incorporated. As a result, the NPV with some other benefits can be incorporated into the compensation package. The NPVs represent the expected value discounted at present time. So, the amount can be given as a compensation package to retire the project earlier than the usual timeline. This thumb rule can also be used in further projects based on financial activities.

The government should incorporate the compensation package from the next budget to slowly phase out coal plants or adopt the early coal retirement plan. The package can be less burdensome for the government with better negotiation and bargain with international climate-related organisations and funders. As several countries are in the process of phasing out coal by initiating regional cooperation, we suggest the government adopt such policies and negotiate the amount from the funders. Also, to strengthen the rationale behind the early coal retirement plan, the government should undertake several health hazard-related studies in the geographical location of coal-based power plants.

From a technical point of view, the government of Bangladesh should focus on feasibility studies to transform the ongoing projects of coal to be operated as an alternative energy source. This cannot be LNG rather any other renewable energy such as solar, wind, among others. To minimise the initial fixed cost loss, the technical infrastructure can be mutated into a structure for renewable energy. This assumption needs to be further researched and tested by experts to reuse the current diaphragms. Also, there is an opportunity for costal area power plants to be transformed into wind winery plants. To achieve an economy of scale, such possibilities need to be assessed with demonstrated research.

The labour market aspects of coal-fired power plants are the other significant factor that needs incorporation, as well. The domestic coal power plant consists of a huge number of semi-skilled labour market. Scrapping the plant will eventually end up being the phenomenon of job loss for those engaged labourers. The government needs to introduce a compensation package for them or relocate them to a different sector based on their set of skills. Also, a proper policy needs to be incorporated which will derive the prospects of the labour market. Necessary training and workshops are recommended to organise as a part of capacity development to reassign the labour force to alternative energy plants.

Future research and policy development must consider a just transition for coal-dependent populations. Future works must focus on developing specific and adequate financial mechanisms for coal retirement, as well as building supportive governmental frameworks for Bangladesh.

In the case of combating the short-term to medium-term responses, the government needs to shift from import-based energy sourcing to domestic options. Apart from resourcing gas from domestic options, further financial promotion of clean energy or renewable energy is required. The recent import volume of LNG is higher which is a costly import, and it needs to be altered soon. The environmental externality of LNG has been negative, also. So, LNG should never be considered as an alternative for coal phase out. Rather proper infrastructure and financial investments should be reinforced for promoting and establishing renewable energy as the major source of supply in the upcoming decades.

References

Abadie, L., Gonzalez-Eguino, M., & Chamorro, J. (2010). Optimal Abandonment of Coal-Fired Stations in the EU. *BC3 Working Papers*.

Ahmed, S., Azhar, S., Castillo, M., & Kappagantula, P. (2000). *“Construction delays in Florida: An Empirical study”.* Florida: Department of Community Affairs.

Alam, J., Ahmed, A., Khan, M., & Ahmed , B. (2011). Evaluation of possible environmental impacts for Barapukuria Coal Power Plant thermal power plant and coal mine. *Journal of Soil Science and Environmental Management, 2*(5), 126-131.

BWGED. (2021). *Bangladesh Working Group on External Debt.*

Chowdhury, A., Deshmukh, R., Wu, C., Uppal, A., Milleva, A., Curry, T., . . . Ndhukula, K. (2022). Enabling a low-carbon electricity system for Southern Africa. *joule, 6*(8), 1826-1844.

Chronopoulus, M., Reyck, B., & Siddiqui, A. (2011). Optimal investment under operational flexibility, risk aversion, and uncertainty. *European Journal of Operational Research, 213*(1), 221-237.

Climate Action Tracker. (2017). *Country assessment: EU.*

Climate and Electricity Annual . (2011). *Early retirement of coal-fired generation in the transition to low-carbon electricity systems.*

Climate Champions. (2021, November 21). Today’s Top of the COP: The Energy Transition. Retrieved September 21, 2022, from https://climatechampions.unfccc.int/todays-top-of-the-cop-the-energy-transition/

CRI. (2021). *Climate Risk Index.*

Davies, R., Holladay, S., & Sims, C. (2022). Coal-Fired Power Plant Retirements in the United States. *University of Chicago Press Journals, 3*.

Doraisami, S., Akasha, Z., & Yunus, R. (2015). A Review on Abandoned Construction projects: Causes and Effects. *Applied Mechanics and Materials, 773*, 979-983.

European Comission. (2018). *Governance of the Energy Union.*

Fouquet, R., & Pearson, P. (2012). Past and prospective energy transitions: Insights from history. *Energy Policy, 50*, 1-7.

Galgóczi, B. (2019). Phasing out coal –a just transition approach. *Working Paper-European Trade Union*.

Haggerty, J., Haggerty, M., Roemer, K., & Rose, J. (2018). Planning for the local impacts of coal facility closure: Emerging strategies in the U.S. West. *Resources policy, 57*, 69-80.

Haggerty, J., Haggerty, M., Roemer, K., & Rose, J. (2018). Planning for the local impacts of coal facility closure: Emerging strategies in the U.S. West. *Resources Policy, 57*, 69-80.

Horn, A., Kjærland, F., Molnar, P., & Steen, B. (2015). The use of real ´option theory in Scandinavia’s largest companies,. *International Review of Financial Analysis, 41*, 74-81.

Jarrett, J. (2007). An Abandonment Decision Model. *The Engineering Economist, 19*(1), 35-46.

Kefford, B., Ballinger, B., Lopez, D., Greig, C., & Smart, S. (2018). The early retirement challenge for fossil fuel power plants in deep decarbonisation scenarios. *Energy policy, 119*, 294-306.

Maamoun, N., Chitkara, P., Yang, J., Shrimali, G., Busby, J., Shidore, S., Urpelainen, J. (2022). Identifying coal plants for early retirement in India: A multidimensional analysis of technical, economic, and environmental factors. *Applied Energy, 312*.

Nedopil , C., Springer, C., Volz, U., & Yue, M. (2022). *The Potential for Early Coal Plant Retirement.* GCI Policy Brief.

OECD. (2017). *OECD Environmental Performance Reviews: Estonia.*

Rambaud, S., & Perez, A. (2016). Assessing the Option to Abandon an Investment Project by the Binomial Options Pricing Model. *Advances in Decision Sciences*.

Rashid, H., Hossain, M., Urbi, Z., & Islam, M. (2014). Environmental Impact of Coal Mining: A Case Study on the Barapukuria. *Middle-East Journal of Scientific Research, 21*(1), 268-274.

Robichek, A. A. & Horne, J. C. V., (2016). Abandonment Value and Capital Budgeting. T*he Journal of Finance, Vol. 22, No. 4 (Dec. 1967),* pp. 577-589.

Shearer, C., Fofrich, R., & Davis, S. (2017). Future CO2 emissions and electricity generation from proposed coal-fired power plants in India. *Earth's Future, 8*(4), 408-416.

Shrimali, G. (2020). Making India's power system clean: Retirement of expensive coal plants. *Energy Policy, 139*.

Steyn, G., Tyler,, E., Roff, A., & Renau, C. (2021). The just transition transaction: a developing country coal power retirement mechanism. *Merdian economics*.

Tong, D., Zhang, U., liu, F., & Geng, G. (2018). Current Emissions and Future Mitigation Pathways of Coal-Fired Power Plants in China from 2010 to 2030. *Environment Science and Technology, 52*(21), 2905–1291.

Wang, X., & Lo, K. (2022). Political economy of just transition: Disparate impact of coal mine closure on state-owned and private coal workers in Inner Mongolia, China. *Energy Research & Social Science, 90*.

Weller, S. (2018). Just transition? Strategic framing and the challenges facing coal dependent communities. *Sage, 37*(2).

Wuebbles, D., & Jain, A. (2001). Concerns about climate change and the role of fossil fuel use. *Fuel Processing Technology, 71*(1-3), 99-119.

Yap, E. (2013). *Causes of Abandoned Construction Projects in Malaysia.* UniversitiTunku.

Zervos, M., Oiviera, C., & Duckworth, K. (2018). An investment model with switching costs and the option to abandon. *Mathematical Methods of Operations Research, 88*, 417-443.

Undoubtedly, coal is harmful for a sustainable future. And based on this ground, the government of Bangladesh is determined to make a transition to an alternative and sustainable source for power generation. However, the transition from coal to an alternative is filled with several challenges and the government must overcome those prior to the transition.

The early retirement of coal-based power plants is an option that has been researched at theoretical and empirical levels. The study revolves around the abandonment decision of a coal plant from the economic perspective and explores necessary guidelines that the government can adopt as a long-term plan.

It also reveals that with the estimated value of the future cash flow, the financial investors can decide whether to abandon a project or sustain it.

CPD Power and Energy Unit
Towards Carbon Neutral Economy

Centre for Policy Dialogue (CPD)
House 40/C, Road 11 (new)
Dhanmondi, Dhaka-1209, Bangladesh
Telephone: (+88 02) 48118090, 55001185, 58156979
Fax: (+88 02) 48110414 E-mail: info@cpd.org.bd
Website: www.cpd.org.bd