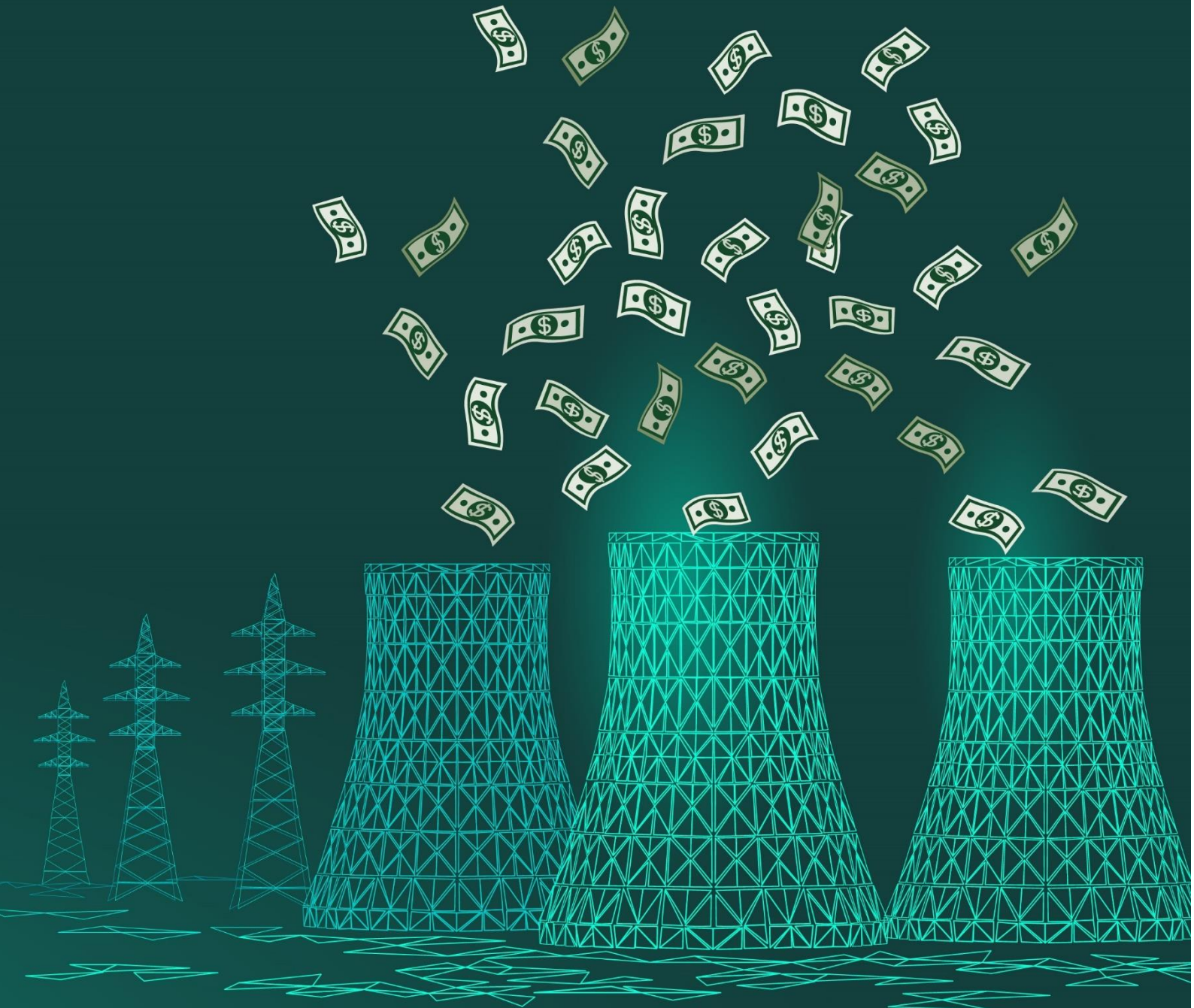




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# Monetizing Externalities of Coal-Based Power Generation in Pakistan

Zainab Babar, Muhammad Umer & Dr Khalid Waleed



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First edition: October 2025 © 2025 by the Sustainable Development Policy Institute

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# Acknowledgements

We would like to express our sincere gratitude to the following organizations and individuals for their invaluable contributions during the consultative discussions:

- Private Power Infrastructure Board, Ministry of Energy (Power Division), Government of Pakistan
- Central Power Purchasing Agency (CPPA-G)
- Power Planning and Monitoring Company, Ministry of Energy (Power Division), Government of Pakistan
- Powering Past Coal Alliance
- Renewables First
- Policy Research Institute for Equitable Development
- Indus Consortium

We also acknowledge the invaluable technical support and insights provided by SDPI experts Engr. Ubaid ur Rehman Zia and Sarim Zia, whose contributions greatly enhanced the quality of this work.

Additionally, we extend our appreciation to Mr. Saleem Khilji, Senior Editor (Research Publications), for his editorial guidance, and the MIS team, including Mr. Adnan Hassan and Mr. Hamza Baig, for their critical role in the project's success. We are also grateful to the Administration Unit, including Mr. Nisar Ahmed and Mr. Imran Khan, for their continued support throughout the process.

Lastly, we would like to recognize the creative input of Mr. Umair Hassan, Graphic Designer, for his excellent work in visually presenting the report.

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# Executive Summary

Behind every unit of electricity produced from coal lies a hidden cost, one that materializes as significant environmental degradation, increasing public health expenditures, and ballooning fiscal pressure on the economy. These are the costs that market prices fail to reflect or internalize. These externalities, primarily caused due to greenhouse gas emissions, airborne pollutants, and resources depletion, have far-reaching consequences for public health, environment, and economy. This study conducts a monetary assessment of the external cost associated with coal power generation and transportation, including climate damages, health impacts, and transport emissions from coal supply chains.

Monetizing these externalities enables the integration of hidden costs into economic decision-making and policy formulation, especially through mechanisms like carbon pricing or Pigouvian taxes. The study also presents a comparative analysis of external costs associated with local and imported coal; based on calculations from two coal power plants (Sahiwal Coal Power Plant & Engro Powergen Thar).

By measuring carbon emissions, health impacts, and transport emissions, the study calculates the external cost per MWh of electricity generated from coal. The findings estimate that the climate damage cost through CO<sub>2</sub> emissions for Sahiwal plant is PKR 8,777.51 per MWh, based on the social cost of carbon (SCC) valuation at PKR 14.21 per kg of CO<sub>2</sub>. The health damage cost associated with coal-fired electricity generation at Sahiwal is estimated at PKR 4,452.27 per MWh. As per the calculations, that the total externality cost for Sahiwal plant is Pkr 17,058.27 per MWh.

For Engro Powergen Thar, the total external costs are higher due to lower efficiency and higher coal consumption. The climate damage cost is estimated at PKR 30,609.05 per MWh, while the health cost amounts to PKR 7,123.63 per MWh. The estimates reveal that the total externality cost for Engro Powergen Thar is PKR 37,732.68 per MWh. The comparative analysis shows that Engro Thar plant, using local lignite coal, incurs double the external costs compared to Sahiwal plant due to the lower calorific value and higher emissions of local coal. The numbers emphasize the need for internalizing externalities in energy pricing structure to reflect the actual cost of coal power generation, which could drive more sustainable energy investments and policies.

This study highlights the urgent need for policy instruments like carbon pricing or Pigouvian taxes to internalize the hidden externalities associated with coal-based electricity generation in Pakistan. These unaccounted costs, ranging from environmental degradation to public health damage, are currently externalized, distorting market pricing and misleading the path for the continuation of coal use despite its significant long-term consequences. The application of Pigouvian taxes, rooted in A.C. Pigou's economic theory, would force coal emitters to pay for the societal costs of their emissions, which are currently hidden from the market.

Globally, carbon pricing has evolved from a contentious debate to a fiscal necessity. Countries like Sweden, Canada, and Singapore have successfully used carbon taxes to reduce emissions and finance clean energy investments. Singapore started its carbon tax journey in 2019 with an initial rate of SGD 5 per ton of CO<sub>2</sub>, progressively increasing it to SGD 25 per ton in 2024, and aiming for SGD 50–80 per ton by 2030. This progressive approach led businesses to adopt cleaner technologies while securing funding for green initiatives. Singapore's strategy serves as a model for Pakistan, suggesting how carbon taxation can raise funds for climate-resilient infrastructure, green finance innovations, and social safety nets for vulnerable communities.

The International Monetary Fund (IMF), through its Resilience and Sustainability Facility (RSF), offers Pakistan an opportunity to introduce carbon pricing while unlocking concessional finance as well. Countries like Costa Rica and Rwanda have already utilized the RSF for climate reforms, showcasing its potential as a financial catalyst for climate-friendly structural changes in energy sector of Pakistan.

Based on the findings, the study suggests that coal plants should be repurposed into renewable energy hubs by utilizing existing infrastructure for solar, wind, and battery storage. A differentiated carbon tax should be introduced, with PKR 37.73/kWh for local coal and PKR 17.07/kWh for imported coal, which reflects true social costs. The study further suggests that a cost-reflective dispatch framework should be set up to integrate health and environmental externalities into energy planning. Revenues from carbon taxes should also be redirected to green projects, rural electrification, and social safety nets. The Resilience and Sustainability Facility (RSF) should be a supporting mechanism to finance this transition while maintaining fiscal stability.

# Abbreviations & Acronyms

<b>CCR</b>	<b>Coal Consumption Ratio</b>
<b>CPPA-G</b>	Central Power Purchasing Agency
<b>CH<sub>4</sub></b>	Methane
<b>CO</b>	Carbon monoxide
<b>CO<sub>2</sub></b>	Carbon dioxide
<b>CO<sub>2</sub>e</b>	Carbon dioxide equivalent
<b>GHG</b>	Greenhouse Gas
<b>ISO</b>	International Organization for Standardization
<b>JETPs</b>	Just Energy Transition Partnerships
<b>kWh</b>	Kilo Watt Hour
<b>MAC</b>	Marginal Abatement Cost
<b>MMT</b>	Million Metric Tons
<b>MoCC &amp; EC</b>	Ministry of Climate Change and Environmental Coordination
<b>MoE</b>	Ministry of Energy (Power Division)
<b>MWh</b>	Mega Watt hour
<b>NTDC</b>	National Transmission and Dispatch Company
<b>NEPRA</b>	National Electric Power Regulatory Authority
<b>NO<sub>x</sub></b>	Nitrogen oxides
<b>N<sub>2</sub>O</b>	Nitrous oxide
<b>PM 2.5</b>	Particulate matter of diameter 2.5
<b>SO<sub>2</sub></b>	Sulphur dioxide
<b>TWh</b>	Terawatt hour

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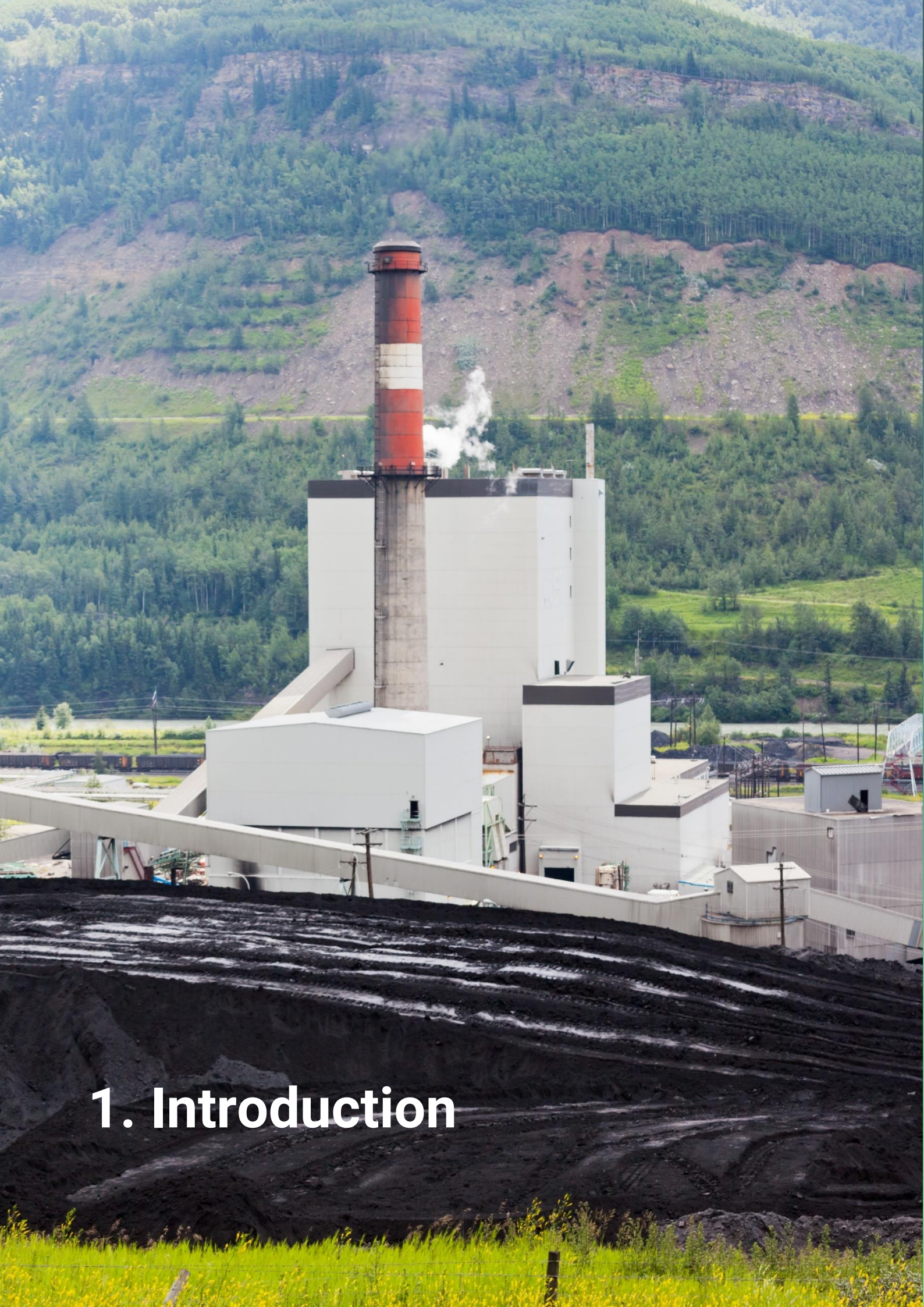
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# 1. Introduction

Coal continues to be a dominant source of fuel in the global energy mix. In 2024, its demand grew by 1.2%, which is equivalent to an increase of 67 million tons of coal equivalent (Mtce). Driven mainly by electricity generation, this rise has been largely spurred by record-breaking temperatures, which have significantly increased the energy demand for cooling. The electricity sector mainly drives the coal demand, accounting for two-thirds of global consumption. Though the share of coal in global power generation decreased to 35% in 2024, it is still a major source of energy (Global Energy Review, International Energy Agency, 2025). Despite the global shift toward clean energy sources, this reliance illustrates the complexities surrounding the energy transition.

The growing coal consumption is a popular trend in Asia where India and China alone accounted for nearly 80% of global coal consumption in 2024 (IEA, 2024). In Southeast Asia, countries such as Indonesia, the Philippines, and Vietnam have seen continued growth in coal demand. This growth is largely driven by the industrial sector such as nickel producers in Indonesia, and coal-fired power generation in the Philippines and Vietnam. On the contrary, developed economies like the European Union are hellbent on reducing their coal consumption, with the United Kingdom phasing out its last coal power plant in 2024. This transition reflects a mega trend in high-income countries towards the adoption of renewable energy sources.

Despite regional disparities in coal demand, the expansion of renewable energy continues to outpace the coal generation. In 2024, an increase in wind, solar, and nuclear power generation surpassed the coal power generation by a significant margin, which keeps the promise for a future with reduced coal dependency. However, coal remains integral to the energy mix of many developing countries where it is still seen as the most cost-effective option to meet energy demand. The perception of coal as an affordable energy source often overlooks the 'external costs' or 'hidden costs' – the environmental, social, and economic burdens associated with coal power generation.

In Pakistan, coal is the third-largest energy source, which accounts for 15.4% of the country's total energy consumption (Government of Pakistan 2024). With the seventh-largest coal reserves in the world, Pakistan's coal consumption reached 0.62 EJ in 2024, ranking the country 12th in the Asia-Pacific region (Tang et. Al., 2024). The increasing reliance on coal causes big challenges for the country's long-term economic sustainability due to its environmental and health impacts. The current pricing framework for coal-based power generation does not account for these hidden costs, resulting in an artificially low price for coal-generated electricity. This makes coal a preferred choice despite the long-term costs it imposes on public health, environment, and economic stability.

Pakistan's dependence on coal for powering key industries, coupled with the country's growing energy needs, complicates efforts to transition towards clean energy sources. With the pressure from the climate commitments to reduce carbon emissions, and the environmental and resource constraints impeding economic growth and damaging the ecosystem, it becomes imperative to evaluate the actual cost or the "External Cost" of coal power generation. The negative externalities, including health impacts and environmental degradation, must be quantified and incorporated into a revised pricing framework that better reflects the true economic and societal costs.

Coal combustion releases a wide array of pollutants, including particulate-matter, sulphur dioxide, nitrogen oxides, mercury, and carbon dioxide. These pollutants cause respiratory illnesses, cardiovascular diseases, premature mortality, and ecosystem damage (World Health Organization [WHO] 2022). The CO<sub>2</sub> emissions from coal accentuates the impacts of climate change, which results in long-term risks to environmental sustainability and economic stability.

Despite the heavy environmental and health externalities, coal remains widely used due to its abundance and the urgent need to address energy deficits. In Pakistan, coal is perceived as a seemingly pragmatic solution for energy security (Khan, Ahmed & Rafiq 2022). Moreover, existing infrastructure, political considerations, and economic factors often delay the transition to clean energy sources.

Accurately estimating the external costs of coal is critical for informed policymaking and the design of effective energy strategies. Incorporating externalities into cost assessments enables governments and stakeholders to recognize the indirect economic burden of coal power and prioritize investments in cleaner and sustainable alternatives (Clean Air Asia 2023). Managing these externalities through regulation, carbon pricing, and technology innovation is essential to align energy development with environmental protection and public health goals.

In this context, this study analyses and quantifies the external costs associated with coal power generation with a focus on the local and imported coal being used in Pakistan for power generation. It synthesizes existing academic research, economic assessments, and environmental data to provide a comprehensive understanding of coal's externalities. The report further discusses the methods to internalize these externalities into the pricing framework for coal power generation.

## **1.1. Understanding External Costs and Planning Myopia in Coal Power Generation**

Continued investments in coal-fired power plants is because of a narrow planning focus that prioritizes immediate financial costs over the full spectrum of societal impacts. This planning myopia overlooks the significant hidden costs, also known as externalities which are associated with coal power generation, including environmental degradation and public health damages. Such oversight promotes the carbon lock-in, creating inertia that further creates barriers in transition towards clean energy sources.

Planning power generation involves a large amount of money and resources with research interest for many (Connolly et al. 2010; Koltsaklis et al. 2014; Koltsaklis and Georgiadis 2015). Initial plant planning is primarily about choosing the right technology and capacity of the power plant to invest to meet demands at an acceptable economic cost (Rokhmawati 2021). However, the problem is becoming more complex nowadays with the development of electrical systems and the cost of externalities (Cong 2013; Li, Fang & Chen 2015). Externalities of electricity-generating operations refer to the external costs that the impact is undeclared within the normal pricing system (AIRafea et al. 2016). However, the costs are borne by parties not involved in the activity (Tietenberg and Lewis 2011).

The external costs caused by electricity generation are associated with human health damage, increased morbidity, and mortality (Burnett et al. 2018). Many power planning studies have not incorporated external costs into their electricity planning models (Rentizelas and Georgakellos 2014). Several studies have been carried out to estimate the adverse effects of electricity production (Lee and Kang, 2016). The exclusion of externality cost becomes the argument why investing in fossil fuel power plants seems cheaper than those of power plants with renewable fuels so investment in renewable energy power plants becomes less attractive. Hence, the policies must consider the direct and externality costs of electricity production activities. Much research has calculated air pollution and health costs due to fossil fuel-based power plants.

Various studies used the ExternE model to perform a comparative analysis of the social costs of fossil fuels and new renewable energy power plants. Nasrulah and Kuncoro (2016) conducted an economic assessment for coal-fired and nuclear power plants to calculate the cost of damage and carbon in the externality costs of power plants. However, some power plant planning models have ignored the influence of government policies on power generation development (Cheng et al., 2015), which will influence the power sector's development path by setting capacity targets. Most previous studies have ignored the external costs associated with the costs of health impacts. The studies examined the environmental impact of coal-fired power generation, particularly focused on areas with high particulate-matter (PM) concentrations (Guttikunda and Jawahar 2014).

The study, therefore, has an objective to estimate the economic impact of carbon emissions from coal power generation and transportation; mainly the cost of damages done by these emissions, and the

economic impact of these emissions on human health. It also involves a comparative analysis of external cost for local and imported coal that is used for power generation.

## **1.2. Energy-Environment-Economy (Triple E) Dilemma**

Over the past two decades, Pakistan has invested heavily on increasing its electricity generation capacity. The country's total installed electricity generation capacity reached 42,131 MW by March 2024, with thermal power plants - coal, gas, and oil - constituting the bulk of this capacity, which accounted for around 59.4%. Hydropower makes up 25.4% of the mix while nuclear power and renewables contribute 8.4% and 6.8% respectively (Pakistan Energy Yearbook 2023). Within the thermal category, coal is increasingly becoming the fuel of choice for power generation due to its relative affordability and abundance in the region.

Despite significant investments in coal-based power, Pakistan's energy sector continues to struggle with growing challenges related to electricity affordability and accessibility. The infrastructure needed to support this generation capacity remains underdeveloped. Moreover, the capacity of transmission and distribution (T&D) network remains limited with estimates from the Pakistan Credit Rating Agency (PACRA) suggesting that the T&D infrastructure can only accommodate around 22,000 MW, leaving a shortfall of 9,000 MW during peak demand periods. This mismatch between generation and transmission capacities has caused persistent inefficiencies, frequent power outages, and high economic costs for both the consumers and the government.

The environmental costs associated with coal-based power generation are significant but often overlooked in the economic evaluation of energy projects. Coal combustion is a major source of Greenhouse Gas (GHG) emissions, contributing significantly to the carbon footprint and intensifying the impacts of climate change. Coal-fired plants are responsible for 72% of global electricity sector emissions, and the impact of these emissions is disproportionately felt by developing countries like Pakistan, which are already grappling with environmental challenges such as flooding, heatwaves, and reduced agricultural productivity (International Energy Agency [IEA] 2023).

Beyond GHG emissions, coal-fired plants emit harmful air pollutants, including sulphur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and particulate-matter, all of which degrade air quality and contribute to public health crisis. In urban areas, particularly in cities near coal plants, air pollution causes respiratory and cardiovascular diseases as well as premature mortality. These environmental externalities or the negative impacts that are not accounted for in the market price of coal-fired electricity create a big burden on society and economy. This leads us to the central challenge that Pakistan's energy sector is facing as how to reconcile the urgent need for energy security with the environmental and health costs associated with coal power generation.

The Energy-Environment-Economy (Triple E) model, which recognizes the interplay between energy production, environmental sustainability, and economic growth, provides a useful framework to conceive these challenges. While coal-based power generation provides short-term economic benefits, it imposes long-term costs that blocks the implementation of Sustainable Development Goals (SDGs).

The increasing urgency for global decarbonization has brought attention to the need for market-based solutions such as carbon taxes that can internalize the environmental and health costs of coal energy. Carbon pricing mechanisms allow for the indirect cost of coal-fired electricity to be reflected in market prices, providing economic signals that encourage businesses to shift towards clean and renewable energy sources.

## **1.3. Problem Statement**

In Pakistan, the market price of coal-generated electricity does not account for the environmental and health externalities associated with coal combustion. These externalities, including air pollution, GHG emissions, and public health costs, are significant but remain largely invisible in the pricing structure of

coal-based electricity. The market price reflects only the direct costs incurred by power producers such as fuel costs, labour, and operational expenses. It does not consider the broader societal costs, which are externalized and borne by society at large.

This discrepancy leads to market failure where coal power generation is incentivized despite its negative impact on society and environment. The lack of internalization of these externalities skews economic decision-making leading to the continued operation of inefficient and environmentally harmful coal plants. Moreover, the absence of a mechanism to capture these costs contributes to the persistence of outdated, polluting technologies in the energy sector.

The external costs associated with coal energy include a wide range of impacts, including health care costs from respiratory diseases, the economic burden of climate damages, and the ecological damage caused by carbon emissions. These costs are not reflected in the electricity prices paid by consumers, resulting in a situation where the true cost of coal energy is hidden from market. This not only distorts market signals but also delays the necessary transition to clean energy sources.

## **1.4. Scope of the Study**

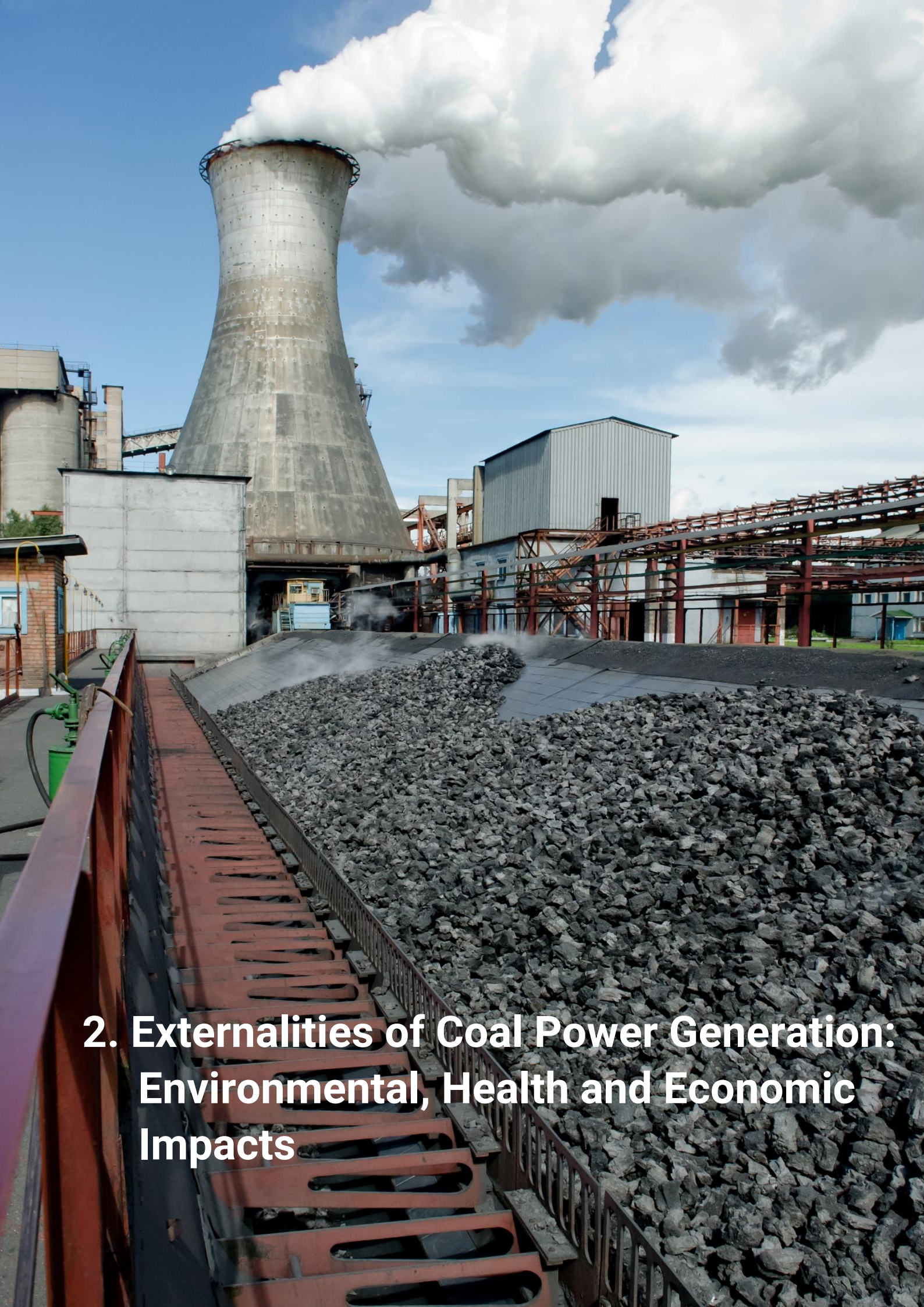
The study examines the often-overlooked external costs embedded within Pakistan's coal-based power generation system. By focusing on both local and imported coal, it aims to uncover the full spectrum of environmental, health, and economic damages that are currently externalized, i.e. excluded from electricity pricing mechanisms and public accounting. These costs, while invisible in market terms, are deeply tangible in societal outcomes.

At its core, the study challenges the assumption that coal remains the most "affordable" energy option. Instead, it discusses the cost structures that have normalized a development model reliant on hidden subsidies—paid not in currency, but in compromised public health and long-term environmental damage.

Key areas of research include

- Monetization and quantification of externalities by estimating the cost of carbon damages while using the social cost of carbon, health-related costs and transportation emissions cost.
- Comparative analysis of local vs. imported coal using key performance indicators such as calorific value, heat rate, and coal consumption per MWh etc. This assessment will evaluate differential impacts, cost profiles, and associated externalities to determine whether a shift from imported to local coal is economically viable.
- Policy relevance by exploring how market-based tools such as carbon pricing, revised tariff structures, and targeted regulation could internalize externalities and reshape investment signals.

Ultimately, the study aims to generate new empirical insight, besides provoking a policy reckoning: can Pakistan afford to keep ignoring the external cost of coal? Would that be a feasible option to shift from imported to local coal or will it seize this moment to redirect its energy future towards a clean and more equitable pathways?



## **2. Externalities of Coal Power Generation: Environmental, Health and Economic Impacts**

Externalities are defined as the unaccounted and uncompensated impacts of a production process imposed on society or environment, which are not reflected in market pricing (Cai et al. 2019). For electricity generation, externalities primarily consist of the cost of damage to health and the environment caused by pollutant emissions and the cost derived from the impact of climate change due to GHG emissions. These externalities need to be internalized into a market pricing system, often through mechanisms like subsidies or taxes. Evaluating environmental externalities is considered a basis for designing efficient regulations (Wang et al. 2017).

## 2.1 Environmental and Health Impacts of Coal Power Generation

Electricity generation from coal fired power plants is a major source of environmental pollution. In China, coal-fired electricity generation is responsible for significant proportions of national emissions: 30% of CO<sub>2</sub>, 33% of NO<sub>x</sub>, 23% of SO<sub>2</sub>, 8% of particulate matter and 3% of CO (Cai et al. 2019). These emissions pose severe threats to air quality and human health. Globally, coal combustion accounts for a substantial share of energy-related carbon emissions, intensifying climate change and its attendant risks, including extreme weather, sea-level rise, and biodiversity loss.

Pollutants from coal plants contribute to frequent fog and haze events, damaging people's mental and physical health. Long-term consequences include increased mortality from diseases. In China, lung cancer mortality has increased dramatically, and is linked to environmental deterioration from pollution (Wang et al. 2017).

PM 2.5, tiny particles less than 2.5 microns in diameter, is a particularly important concern as it is a known important cause of mortality risk worldwide. Emissions from coal power plants in Southeast Asia were estimated to contribute to tens of thousands of excess deaths annually. There are very well documented relationships between PM 2.5 concentrations and specific diseases by age and concentration levels (Larson, Radford & Gettys 2020). For adults aged 25 to 84, key health risks from PM 2.5 include strokes, heart attacks, and chronic pulmonary obstructions.

The areas where coal power plants are located have higher PM 2.5 concentrations, as these are associated with increased risks of respiratory illnesses, cardiovascular diseases, and other adverse health outcomes for local populations. The environmental and public health impacts of coal-based power generation emphasize the urgent need for pollution control measures and transition to clean energy sources in these vulnerable areas.

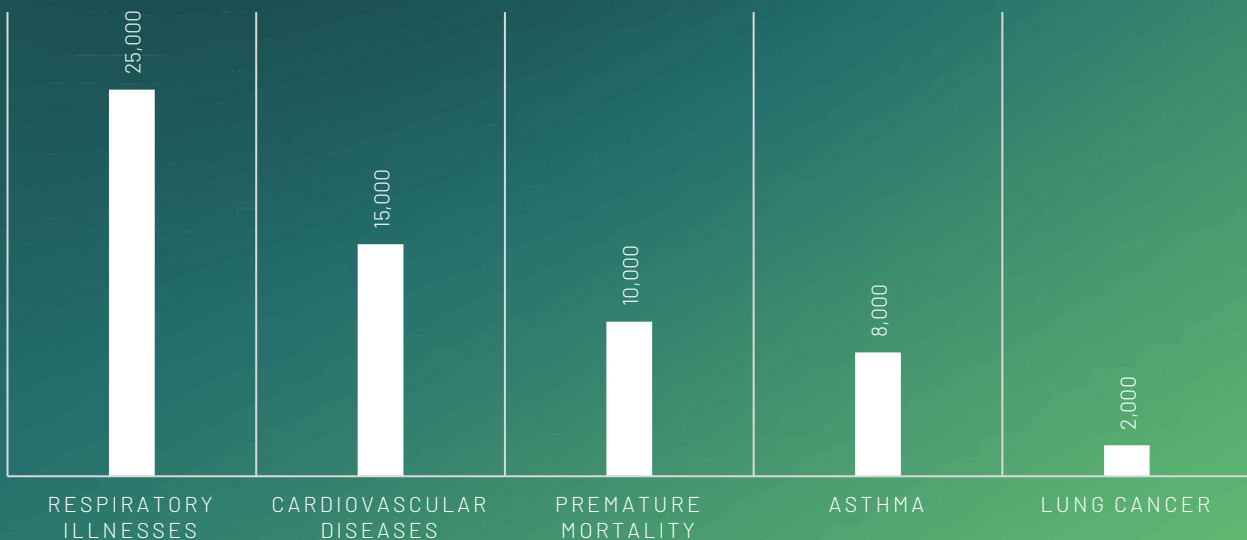


Figure 1-Health Impacts (Estimated Annual Cases Attributed to Coal Emissions)

Source: Clean Air Task Force, 2004, Cheng et al., 2023

SO<sub>2</sub> and NO<sub>x</sub> emissions are the primary drivers in acid rain creation, which can damage soil and crops (Wang et al. 2017; Mahapatra et al. 2012). Environmental damages can also occur to building materials, forests, ecosystems, water, flora, and fauna, though comprehensive assessments might focus on specific impacts like crops and building materials (Mahapatra, Kumar & Mishra 2012).

### Emission Breakdown from Coal Power Plants

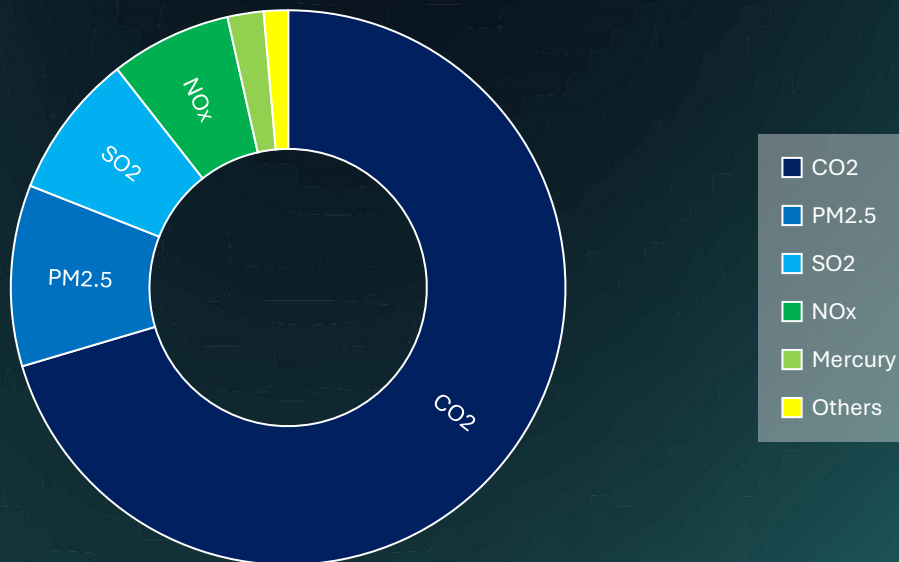


Figure 2-Emission Breakdown from Coal Power Plants

Source: IEA,2025

The above chart represents the emission profile of coal-fired power plants, detailing the proportional contribution of key pollutants. Carbon dioxide (CO<sub>2</sub>) constitutes most emissions, stressing coal combustion as a primary source of anthropogenic GHGs driving global climate change. Sulphur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) are significant contributors, which act as precursors to acid rain and tropospheric ozone formation, with consequential impacts on atmospheric chemistry and ecosystem health. PM<sub>2.5</sub> though lower in mass percentage, is critical due to its respirable size and association with increased morbidity and mortality rates. Mercury emissions, despite representing a smaller emission fraction, are of high concern given their neurotoxic effects and bioaccumulation in food chains. This breakdown provides a comprehensive overview of the diverse and harmful emissions associated with coal power generation, essential for informing mitigation strategies and regulatory frameworks.

## 2.2 Economic Impact of Externalities

Coal power is often perceived economically competitive when only the direct economic cost is considered. However, this perspective changes significantly when external costs are taken into account (Cai et al. 2019; Wang et al. 2017).

Direct economic costs for biomass power in China were estimated at 0.44 Chinese yuan (CNY) per kilowatt-hour (kWh), about 25%–37% higher than that of coal power. However, because of significant GHG emissions and PM<sub>2.5</sub> pollutants during power generation, the external cost of coal-fired power is estimated at 0.17 CNY/kWh on average, substantially higher than that of biomass power (0.06 CNY/kWh) (Cai et al. 2019).

Another study using choice experiments estimated the environmental cost of coal-fired power plants is 0.30 yuan per kWh (11.91 Pkr), based on people's willingness to pay for emission reduction (Wang et al. 2017).

When environmental externalities are included, the economic situation of biomass power reverse [indicating the complete economic cost (direct + external)], can reverse the economic competitiveness scenario. Therefore, a reasonable and comprehensive cost accounting mechanism combining the direct and external economic cost is crucial for accurately understanding the real economic situation of energy production and promoting the development of clean alternatives.

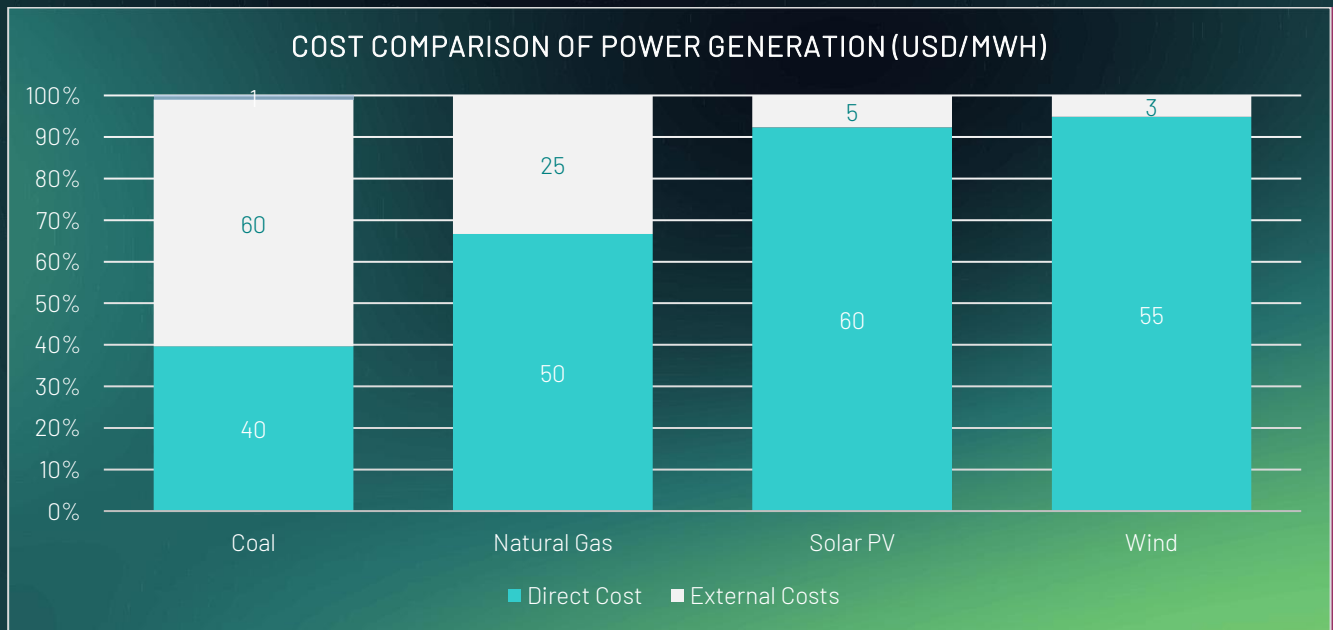


Figure 3-Cost Comparison of Power Generation (USD/MWh)

Figure 4 from the World Bank report, titled: *State and Trends of Carbon Pricing 2023*, offers a compelling visual representation of levelized cost of electricity (LCOE) across various power generation technologies. LCOE is a critical metric that encapsulates the per-megawatt-hour cost of building and operating a generating plant over its assumed financial life and duty cycle. In this graph, coal-fired power generation typically exhibits higher LCOE compared to renewable sources. This disparity arises from factors such as fuel costs, operational expenses, and the necessity for carbon capture and storage (CCS) technologies. Conversely, renewable energy technologies like wind and solar photovoltaics (PV) experienced a decline in LCOE over the past decade. This reduction is attributed to technological advancements, economies of scale, and favourable policy frameworks, making them increasingly competitive with traditional fossil fuels.

Natural gas combined-cycle plants present a middle ground in terms of LCOE, balancing lower emissions with competitive costs. Nuclear energy, while offering a low-emission alternative, carries high capital costs and extended construction timelines, contributing to a higher LCOE. The graph highlights the importance of integrating external costs, such as carbon emissions, into energy pricing. Without accounting for these externalities, fossil fuel-based power generation may appear more cost-effective, potentially impeding the transition to clean energy sources.



### 3. Estimating External Cost of Coal

As discussed in the previous section, coal-fired power generation incurs significant external costs on society that are not reflected in electricity tariffs. These external costs stem primarily from GHG emissions, air pollutants, and resource degradation. To estimate the external or hidden cost of coal-based electricity, this section presents an integrated monetary assessment of climate damage, health externalities, and plant-specific emissions cost differentials between imported and locally sourced coal.

The most critical step in the externality assessment process involves delineating the analytical scope. This foundational phase ensures methodological rigour and transparency in tracing the full spectrum of environmental, health, and social costs associated with coal-based electricity generation. The principal objective is to quantify the hidden costs, the costs that are not captured in market transactions.

These externalities can be broadly categorized into six major domains, each representing a critical dimension of coal's unpriced burden.

- 1- Greenhouse gas emissions - Primarily carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>), which contribute to anthropogenic climate change and global warming.
- 2- Airborne pollutants - Emissions like sulphur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), particulate matter (PM<sub>2.5</sub>), and trace metals such as mercury, which exacerbate respiratory illness and degrade ambient air quality.
- 3- Climate-related damages - Economic and social costs arising from rising temperatures, extreme weather events, and sea level rise.
- 4- Public health burdens - Morbidity and premature mortality caused by exposure to coal-related pollutants.
- 5- Natural resource depletion - Extensive water withdrawals, coal consumption, and land use changes that strain local ecosystems and communities.
- 6- Ecological degradation - Loss of biodiversity, soil contamination, and disruption of natural habitats due to mining and waste disposal.

### 3.1. Monetization of Externalities

To measure the external cost of these externalities, these physical impacts need to be translated into monetary terms. This monetization phase allows for direct integration of external costs into economic decision-making and policy instruments such as carbon pricing or Pigouvian taxation. The figure below presents the scope of the study.

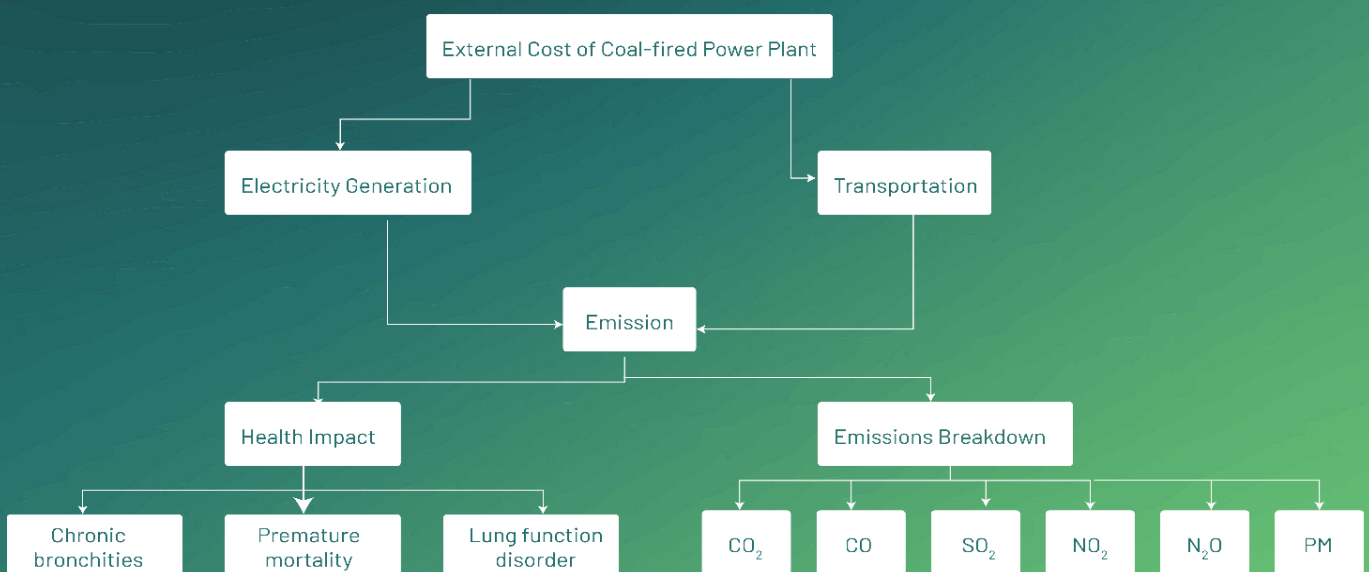


Figure 4- Framework defining the scope of the study

This study undertakes a structured and multidimensional assessment of the external costs associated with coal-fired power plants in Pakistan, anchoring its analysis in emissions from electricity generation to coal transportation. These two processes are the primary drivers of pollutant release, the effects of which ripple through ecosystems, human health systems, and national economic frameworks. Emissions are disaggregated into two core domains of externality, i.e. health and environment; in case of environmental impacts, the study focuses on CO<sub>2</sub> emissions.

These externalities are strongly linked with the amount of coal that is being used to produce electricity. The following graph shows different amounts of local and imported coal that is used to generate electricity. According to NEPRA’s State of Industry Report 2024, as illustrated in Figure 5, a comparison of units generated (measured in terawatt hours, TWh) and quantity of local and imported coal (measured in million metric tons, MMT) is analyzed. It is learnt that the amount of local coal required to generate electricity is comparatively more as compared to the amount of imported coal required to generate same amount of electricity. The difference indicates that approximately double the quantity of local coal is utilized to generate electricity compared to imported coal.

The study selects the following two coal power plants for comparative analysis.

- Sahiwal Coal Power Plant (Imported Sub-bituminous Coal).
- Engro Powergen Thar (Local Lignite Coal).

This analysis allows us to draw meaningful conclusions about the externalities associated with each type of coal.

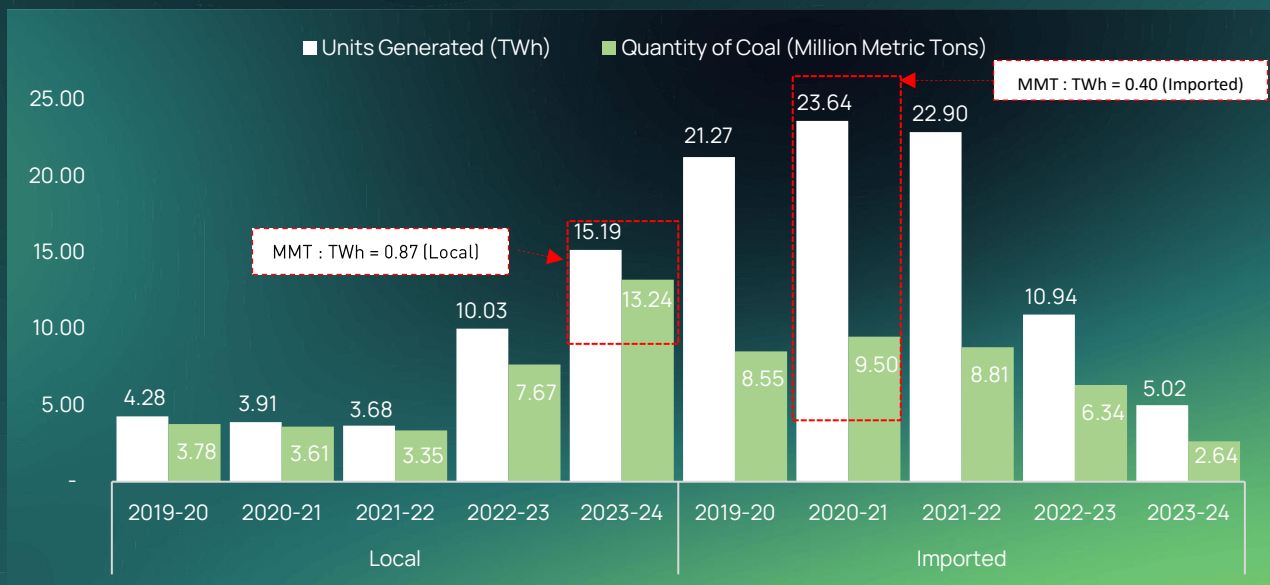


Figure 5: Local vs Imported Power Plants: Units Generated (TWh) & Quantity Required (MMT)

Graph designed by authors based on data from NEPRA, State of Industry (2024)

### 3.1.1. Cost of Climate Damages through CO<sub>2</sub> Emissions

One of the most widely used approaches to value carbon emissions is the Social Cost of Carbon (SCC), which estimates the present value of future damages associated with the emission of one additional ton of CO<sub>2</sub>. By monetizing these damages, SCC provides a robust foundation for calculating the climate-related external cost of fossil fuel-based electricity production.

To estimate this cost in the context of Pakistan, the study uses the SCC value set by the US Environmental Protection Agency (EPA) in 2021, which is \$51 per ton of CO<sub>2</sub> at a 3% discount rate. At the prevailing exchange rate of PKR 278.65 per USD, this translates into PKR 14,211.15 per ton or PKR 14.21 per kilogram of CO<sub>2</sub>.

The CO<sub>2</sub> related external cost is calculated as:

Cost of Climate Damages (PKR /MWh)

= CO<sub>2</sub> Emissions (kg/MWh) × Cost per kg of CO<sub>2</sub> (PKR/kg)

As per data, given below in table 2 for the Sahiwal coal power plant, approximately 617.7 kilograms of CO<sub>2</sub> are emitted for every 1 megawatt-hour (MWh) of electricity generated. Using the SCC-based cost per kilogram of CO<sub>2</sub>, the climate damage per MWh is calculated as follows.

Cost of Climate Damages (PKR/MWh) = 617.7kg CO<sub>2</sub> × 14.21 PKR/kg = PKR 8,777.51 /MWh

This result indicates that for every megawatt-hour of coal-based electricity generated at Sahiwal, society incurs a hidden cost of **PKR 8,777.51**, which is not paid by the producer or reflected in the electricity tariff.

Table 1- Data from Sahiwal Imported Coal Power Plant for 1MWh generation

Input/Output Components	Unit	Coal Transportation Stage	Electricity Generation Stage	Total
<b>Resources (Inputs)</b>				
Coal	Kg	-	375.15	375.15
Limestone	Kg	-	4.00	4.00
Diesel	Liter	2.99	-	2.99
Water	Kg	-	3,330.05	3,330.05
Electricity	kWh	-	50.78	50.78
<b>Emissions (Outputs)</b>				
CO <sub>2</sub>	Kg	85.36	531.91	617.27
CO	Kg	0.021	0.047	0.07
SO <sub>2</sub>	Kg	0.24	0.75	0.99
NO <sub>x</sub>	Kg	0.12	0.40	0.52
N <sub>2</sub> O	Kg	0.40	0.45	0.85
CH <sub>4</sub>	Kg	8.65	0.01	8.66
Total Suspended Particulate (TSP)	kg	-	0.12	0.12
Boiler ash	Kg	-	70.90	70.90
Gypsum Desulfurization (GD)	Kg	-	0.01	0.01
<b>Total Emissions</b>	<b>Kg</b>	<b>94.79</b>	<b>604.60</b>	<b>699.39</b>

(Data Source: Rasheed et al. 2021)

### 3.1.2. Health Impacts and Cost Assessment

Coal-fired power plants not only heavily contribute to climate change but also produce significant amount of air pollutants that pose serious risks to human health. Emissions such as particulate-matter (PM<sub>10</sub>), sulphur dioxide (SO<sub>2</sub>), and nitrogen oxides (NO<sub>x</sub>) have been strongly associated with a spectrum of adverse health effects including chronic bronchitis, respiratory hospitalizations, reduced lung function, and premature mortality. These impacts are not accounted for in the market price of electricity, resulting in hidden societal costs.

To capture these health-related externalities, various studies have quantified health damages by combining pollutant exposure levels with epidemiological risk coefficients and economic valuation per health outcome (Rokhmawati et al. 2023). The findings reveal substantial monetary burdens per health effect, shown in the figure below.



Figure 6- Monetary burdens per health effect.

By integrating these costs, a health damage cost of \$15.98 per MWh is incurred through coal-generated electricity. Converting this to Pakistani Rupees using the prevailing exchange rate (1 USD = PKR 278.65), the external health cost becomes

$$\text{Health Externality Cost (PKR/Mwh)} = 15.98 \times 278.65 = \text{PKR } 4,452.27 / \text{MWh}$$

This number shows the significant but unpriced health burden placed on communities surrounding coal power infrastructure. It also demonstrates that the true societal cost of electricity from coal is significantly higher than its market value.

The externality assessment for Sahiwal coal power plant integrates climate damages, transport emissions, and public health valuations. The key findings include:

### 3.1.3. Transportation Emissions Cost

The transportation of coal adds significant emissions and financial strain to the energy sector. Long-distance transport that relies on diesel-powered trucks and trains, increases the carbon footprint of coal-fired power generation. The diesel transport cost stands at \$2.99 per MWh, which reflects only the direct cost of fuel. The emissions, primarily carbon dioxide, contribute directly to climate change

The analysis focuses on CO<sub>2</sub> emissions, which account for approximately 90% of total emissions during both the stages of transportation and electricity generation. By applying the SCC rate, the study assigns a monetary value to these emissions based on a shadow price of PKR 14.21 per kg of CO<sub>2</sub>. This valuation provides insight into the economic burden of carbon emissions associated with coal-fired power generation. The overall mathematical steps of CO<sub>2</sub> emissions is provided below:

$$\text{Total Coal required kg per MWh} = TQ_{coal}^{kg} = 375.15 \text{ kg/MWh}$$

$$\text{Total CO}_2 \text{ Emissions in kg/MWh} = T_{CO_2(kg)}^{total} = 617.27 \text{ kg/MWh}$$

$$\text{CO}_2 \text{ Transportation Emissions in kg/MWh} = T_{CO_2(kg)}^{Transport} = 85.36 \text{ kg/MWh}$$

$$\text{CO}_2 \text{ Electricity Generation Emissions in kg/ MWh} = T_{CO_2(kg)}^{Elect.Generation} = 531.91 \text{ kg/MWh}$$

$$\% \text{age Share of CO}_2 \text{ Transportation Emissions} = T_{CO_2(\%)}^{Transport} = \frac{T_{CO_2(kg)}^{total}}{T_{CO_2(kg)}^{Transport}} \times 100$$

$$T_{CO_2(\%)}^{Transport} = \frac{617.27}{85.36} \times 100 = 13.8\%$$

$$\% \text{age Share of CO}_2 \text{ Electricity Generation Emissions} = T_{CO_2(\%)}^{Elect.Generation} = \frac{T_{CO_2(kg)}^{total}}{T_{CO_2(kg)}^{Elect.Generation}} \times 100$$

$$T_{CO_2(\%)}^{Elect.Generation} = \frac{617.21}{531.91} \times 100 = 86.2\%$$

Total Emissions Cost in PKR /MWh

$$T_{CO_2(Rs.)} = 14.21 \times 617.21 = 8,770.55 \text{ Rs./MWh}$$

Generation emissions cost = 8,771.41 x 86.2% = 7,558.44 PKR /Mwh

Transportation emissions cost = 8,771.41 x 13.8% = 1,212.97 PKR / Mwh

Total External Cost

The external cost for electricity generated from imported coal will be

$$\text{Total Externalities Cost in PKR / kWh} = T_{\text{Externalities}} = \frac{T_{CO_2(Rs.)}^{\text{Transport}} + T_{CO_2(Rs.)}^{\text{Elect.Generation}} + \text{Health Cost}}{1000}$$

$$T_{\text{Externalities}} = \frac{1,212.97 + 7,558.44 + 4452.27}{1000} = 13.22 \text{ Rs./kwh}$$

The next step after estimating the total external cost and monetization of climate damages, health-related costs and transport emissions cost, is to apply this framework to real-world data. The next section quantifies these externalities using fuel consumption, tariff-indexed emission factors, and social cost of carbon values for two coal power plants in Pakistan, Sahiwal (imported coal) and Engro Powergen Thar (local coal). This approach allows for a direct comparison of the environmental and economic burdens associated with different fuel sources and combustion efficiencies.

### 3.2. Comparative Analysis of Coal Power Generation from Local Vs Imported Coal

To assess the externalities associated with coal-based electricity generation, this section uses tariff-indexed operational parameters sourced from NEPRA. By grounding the analysis in performance metrics of power plants specifically the calorific value and thermal efficiency, this method facilitates a plant-specific quantification of emissions and external costs. It draws a comparative line between two power plants, i.e. the Sahiwal Coal Power Plant (reliant on imported sub-bituminous coal) and the Engro Powergen Thar Plant (which utilizes local lignite). This approach not only enhances contextual accuracy but also unveils how variations in coal type and plant efficiency directly influence external burdens.

Various parameters were used for comparative analysis, e.g. calorific value, which indicates the energy content in coal and is measured in BTUs per kilogram. Higher values imply more energy can be extracted per unit of coal, resulting in fewer emissions per MWh. Whereas thermal efficiency reflects how effectively a power plant converts coal energy into electricity. Higher efficiency lowers fuel demand per unit of electricity, reducing emissions. The performance data is presented below:

Table 2- Calorific Value & Thermal Efficiency

Plant Parameters		Engro Powergen Thar	Sahiwal Imported Coal
<b>Calorific Value (BTUs/kg) for Oct-Dec 2024 Qtr. (Revised)</b>	$CV_{BTU/kg}$	10,710	22,282.64
<b>Thermal Efficiency</b>	(%)	37	39

(Data Source: NEPRA, (2025))

The heat rate, expressed in TJ/MWh, is calculated based on the calorific value and thermal efficiency. It represents the amount of energy required to produce one megawatt-hour (MWh) of electricity. This calculation provides insight into the energy efficiency of each plant and sets the step for estimating CO<sub>2</sub> emissions.

$$\text{Heat Rate TJ per MWh} = HR_{TJ/MWh} = \frac{3600}{\text{Thermal Efficiency (\%)} \times 10^6}$$

The total CO<sub>2</sub> emissions are calculated based on the heat rate and the IPCC emission factors, which provide standardized estimates of carbon emissions per unit of energy produced. The IPCC emission factors are calculated in terms of tons of carbon per TJ of energy produced. This factor is essential for converting energy input into expected CO<sub>2</sub> output (Simmons 2003). The data on emission factors for both lignite coal and sub-bituminous coal is provided in the Table below:

Parameter		Engro Powergen Thar	Sahiwal (Imported Coal)
<b>Calorific (BTU/kg)</b>	<b>Value</b> Calorific value indicates the energy content in coal and is measured in BTUs per kilogram. Higher values imply more energy can be extracted per unit of coal, resulting in fewer emissions per MWh.	10,710	22,282.64
<b>Thermal Efficiency (%)</b>	Thermal efficiency reflects how effectively a power plant converts coal energy into electricity. Higher efficiency lowers fuel demand per unit of electricity, reducing emissions.	37	39
<b>Heat Rate (TJ/MWh)</b>	The heat rate measures the amount of energy required as input for generating a unit of electricity output, it is computed using the calorific value and thermal efficiency. It is expressed in TJ/MWh and BTU/MWh.	$HR_{TJ/MWh} = \frac{3600}{\text{Thermal Efficiency (\%)} \times 10^6} = 0.00972$	0.00923
<b>Heat Rate (BTU/MWh)</b>		$HR_{BTU/MWh} = HR_{TJ/MWh} \times 0.947817 = 9,222,003.24$	8,749,080 BTU/MWh
<b>Coal Requirement Kg Per MWh</b>	Due to its lower calorific value and thermal efficiency, the Engro plant requires more coal to generate the same electricity output.	$TQ_{coal}^{kg} = \frac{HR_{BTU/MWh}}{CV_{BTU/kg}} = 861.06$	392.64
<b>Coal Consumption Ratio (CCR)</b>	This ratio helps adjust emissions and transportation costs for local lignite.	$CCR = \frac{TQ_{CO_2}^{kg}(\text{Engro Powergen})}{TQ_{CO_2}^{kg}(\text{Sahiwal Coal})} \approx 2.193$	
<b>Emissions Factors</b>	Using IPCC guidelines, the emission factors for each coal type are:	Lignite (local) 27.6 (t-C/TJ) * 2.19 (CCR) = 60.44	Sub-bituminous 26.2 (t-C/TJ)
<b>CO<sub>2</sub> (kg/MWh)</b>	Emissions for generating 1 MWh of electricity $CO_2 \text{ (kg/MWh)} = \text{Heat Rate (TJ/MWh)} \times \text{Emission Factor (t-C/TJ)} \times (44/12) \times 1000$	$0.00972 \times 60.44 \times 3.6667 \times 1000 = 2154.05$	$0.00923 \times 26.2 \times 3.6667 \times 1000 = 887$
<b>CO<sub>2</sub> Cost Estimation (kg/MWh)</b>	$= CO_2 \text{ (kg/MWh)} \times \text{Cost of Climate Damages (Rs/kg)}$	$2154.05 \text{ kg/MWh} \times 14.21 \text{ PKR /kg} = 30,609.05$	$887 \text{ kg/MWh} \times 14.21 \text{ PKR /kg} = 12,606.27$

This method offers a layer of verification to the earlier SCC-based valuation and emphasizes how coal quality and combustion technology significantly influence emissions intensity. For instance, due to its lower calorific value and higher moisture content, lignite coal used at Engro Thar results in more than double the CO<sub>2</sub> emissions per MWh compared to the sub-bituminous coal used at Sahiwal.

By applying the SCC rate of PKR 14.21/kg CO<sub>2</sub> to the emissions estimated through this framework, we can derive a plant-specific monetary valuation of climate damages that aligns operational realities with global carbon pricing standards. This dual-method approach not only enhances transparency but also strengthens the rationale for differentiated carbon regulation based on plant performance and fuel type.

Table 3- Cost Comparison; Local Vs Imported Coal

Component	Sahiwal (PKR/MWh)	Engro (Rs./MWh)
CO <sub>2</sub> Emission Cost	12,606.27	30,609.05
Health Cost	4,452.27	7,123.63
<b>Total Externality Cost (PKR/MWh)</b>	17,058.27	37,732.68
<b>Total Externality Cost (PKR/kWh)</b>	17.05	37.73

This comparative analysis reveals that both plants incur substantial externality costs. The Engro Thar plant experience higher overall burden due to its lower efficiency and higher coal consumption. These results support the need for carbon pricing or Pigouvian taxes to internalize these hidden costs. The externalities make a compelling case for transitioning toward cleaner energy alternatives and re-evaluating coal's role in Pakistan's power sector.

### The Coal Swap Dilemma: Smart Move or a Costly Detour?

Pakistan is on the pivot of high stakes since it is shifting from imported coal to locally mined Thar coal to fuel its power plants, particularly those financed and operated under the China-Pakistan Economic Corridor (CPEC). On paper, this appears to be a strategic decision to reduce import dependence, save foreign exchange, and bring down electricity costs.

Based on various calculations, Thar coal is cheap only if we ignore what it costs (direct+ indirect). Once you account for its low calorific value, higher emissions, and high external cost; polluted air, health impacts, and climate damage—the so-called savings evaporate. What seems like an energy security solution becomes a social and environmental liability. Simply put, Pakistan may be swapping one problem for another, locking itself into a future of costlier power.

Instead of doubling down on domestic coal, the wise and sustainable strategy would be to repurpose existing coal plants for renewable integration. Globally, countries are converting coal infrastructure into hybrid clean energy hubs, pairing solar or wind with battery storage, using existing transmission lines and land. Pakistan, with its vast solar potential and growing grid challenges, stands to gain far more from this pivot than it does from clinging to a fading fuel.

### 3.3. Internalizing Externalities through Pigouvian Taxation

The study findings stress the need for policy instruments such as carbon pricing or Pigouvian taxes to internalize the unaccounted externalities or the hidden costs that are embedded within coal-based electricity generation. The stark magnitude of these hidden costs not only justifies fiscal intervention but also amplifies the imperative for a decisive shift toward cleaner and more sustainable energy alternatives. In this context, Pakistan's continued reliance on coal entails critical re-evaluation, especially considering the escalating environmental and public health toll it imposes.

In the 1920s, British economist, A.C. Pigou, suggested that each emitter should pay the societal cost of the damage caused by their emissions via an appropriate price. Pigouvian taxes represent a corrective instrument designed to address market failures by internalizing negative externalities. These are not only fiscal tools but also economic signals that attempt to bring the invisible costs of pollution and degradation into the decision-making calculus of firms and consumers. In the realm of environmental governance, carbon pricing serves as the most illustrative case that urges the emitters to reckon with the true cost of GHG emissions that have long been externalized to society. The following graph shows the difference between market price and the actual price if we include the hidden/social cost.

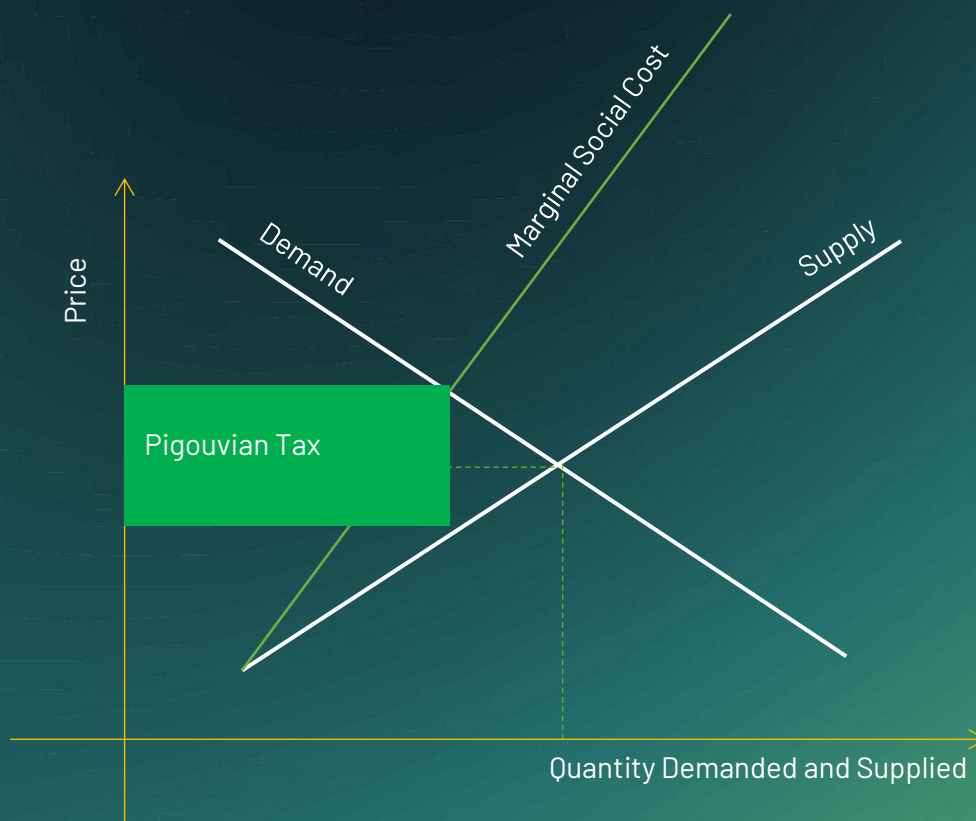


Figure 7-Pigouvian Tax

### 3.4. Global Shift Toward Pricing Carbon

The paradigm of economic growth is being redefined by an urgent imperative that is the **polluters must pay**. Carbon pricing, whether in the form of taxes, cap-and-trade systems, or hybrid schemes, has become the central policy lever in the fight against climate change. What was once seen as politically unpalatable is now increasingly viewed as economically inevitable and fiscally prudent.

Sweden, often cited as the gold standard, has been maintaining a carbon tax since 1991. Now, it has surpassed \$130 per ton of CO<sub>2</sub> while simultaneously achieving GDP growth and emissions decline.

Canada's federal framework links carbon pricing with progressive redistribution, returning revenues to households in a move that mitigates inequality while preserving the environmental signal.

In Europe, Denmark has recently imposed a world-first methane tax on livestock, charging €100 per cow by 2030, which is considered a bold attempt to account for agricultural emissions. Similarly, Germany's fuel taxes and France's carbon floor price reflect growing political alignment around carbon accountability.

In Asia, Singapore and South Korea have emerged as regional leaders in carbon pricing by adopting distinct but complementary policy instruments, i.e. carbon taxes and emissions trading systems (ETS).

### **3.4.1. Market-Signal Carbon Tax in Singapore**

In 2019, Singapore made a bold move by introducing its first-ever carbon tax in Southeast Asia. It was set at a modest Singapore Dollar (SGD), i.e. \$5 per metric ton of CO<sub>2</sub>-equivalent. This tax was applied to the facilities emitting 25,000 tons or more annually. While the initial figure seemed relatively small, it was intentionally designed as a "signal price" to nudge corporations towards cleaner practices while giving them the necessary time to adjust. This was just the beginning.

Fast forward to 2024, Singapore's commitment to decarbonization has grown substantially. The carbon tax raised to SGD \$25 per ton, and by 2026–2027, it will hit SGD \$45 per ton. However, the government's ambition doesn't stop here. By the year 2030, the tax could soar to a range of SGD \$50–\$80 per ton, making it one of the highest in Asia. This move is part of Singapore's larger Green Plan 2030, reflecting a clear and strategic escalation of the tax to align with the nation's long-term environmental goals (Singapore's Carbon Trading Tax Costs 2022).

What makes Singapore's approach unique is its broad sectoral coverage, very few sectors are exempt, with the government ensuring that all high-emission sectors pay their share. What's more, the revenue generated from this tax isn't just to fill government coffers. It's strategically funnelled into high-impact initiatives such as hydrogen research, grid transformation, and green finance innovations. The initiative not only meant to raise funds but also to accelerate the transition towards a cleaner energy future while ensuring that businesses remain competitive in a carbon-conscious society.

#### **Tax Evolution: More Than Just a Signal**

The revised carbon tax trajectory, jumping from \$5 to \$25 per ton in 2024, is not simply about revenue generation. It's about forcing businesses to reckon with the true cost of carbon emissions and invest in cleaner technologies. By the time 2030 rolls around, with taxes reaching as high as SGD \$80 per ton, the pressure will be on, compelling businesses to rethink their carbon footprint and embrace green alternatives or risk falling behind.

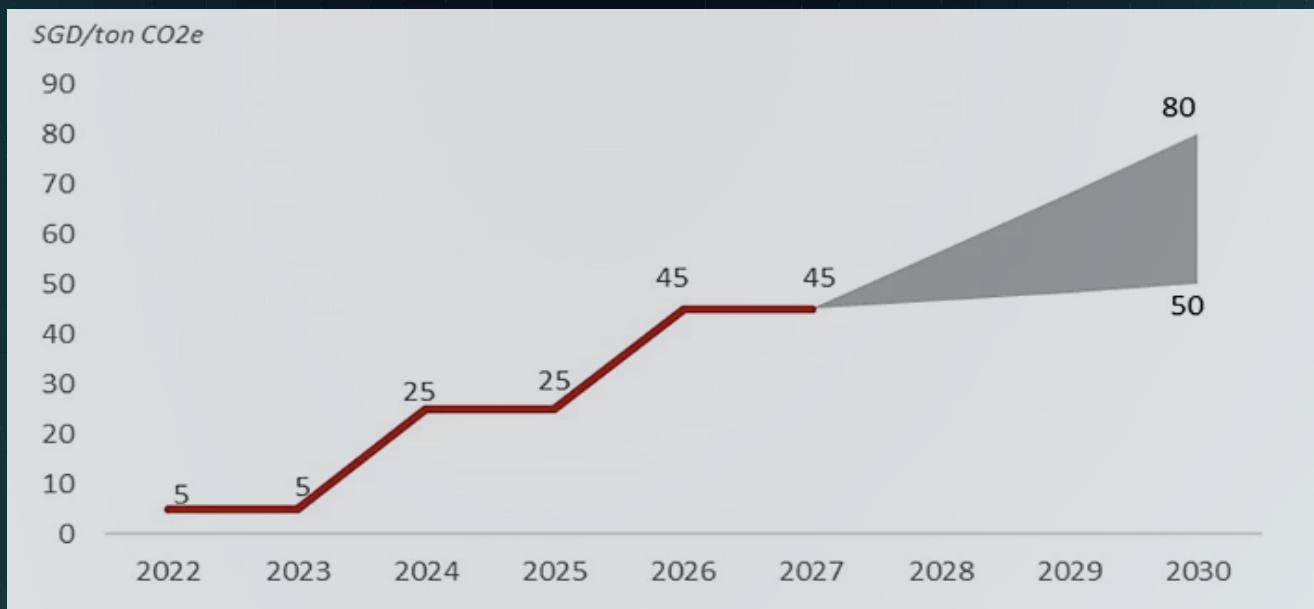


Figure 8- Singapore's Carbon Tax

At the core of this strategy is a vision; to turn carbon pricing from a punitive measure into an essential market signal. With carbon taxes reaching unprecedented heights, businesses will no longer be able to ignore the environmental cost of their operations. Instead, they'll be forced to innovate, adopt cleaner solutions, and ultimately, contribute to a greener economy.

### 3. 4. 2. Role of IMF and RSF in Catalysing Carbon Taxation in Pakistan

The International Monetary Fund (IMF) has become a proponent of carbon pricing. In 2022, it launched the Resilience and Sustainability Facility (RSF) to support climate-related structural reforms in developing countries. Under the RSF, countries can access long-term, low-interest financing in exchange for implementing robust climate strategies, including carbon taxes, fossil fuel subsidy reforms, and climate-resilient infrastructure development. Nations like Costa Rica, Rwanda, and Barbados have already entered RSF agreements that explicitly link disbursements to carbon pricing reforms.

The RSF is more than a loan instrument; it is a structural realignment tool. Countries such as Costa Rica, Rwanda, and Barbados have already entered agreements tying IMF funds to decarbonization strategies, including the introduction or enhancement of carbon pricing mechanisms.

For countries like Pakistan, the RSF offers a path forward, linking macroeconomic stability with climate resilience. Carbon taxes introduced under RSF guidance would not only reduce emissions but also signal to investors and donors that Pakistan is serious about aligning fiscal policy with environmental sustainability.

While conceptually strong, the implementation of Pigouvian tax/carbon tax in Pakistan is challenging. Concerns about economic distortion, political feasibility, and distributive fairness dominate the discourse. Carbon taxes, if untargeted, can disproportionately affect low-income groups who spend a larger share of their income on energy. To overcome the barriers, many countries have embraced revenue-neutrality, channelling tax proceeds into household rebates, green subsidies, or social safety nets, or rural electrification can overcome opposition and deliver inclusive benefits. This design feature enhances political acceptability while preserving the environmental signal.

Despite being highly vulnerable to climate impacts, Pakistan has yet to operationalize Pigouvian principles within its energy sector. While discussions around carbon pricing and emissions trading have gained traction especially with the release of the Policy Guidelines for Carbon Market Trading (Ministry of Climate Change 2023), concrete fiscal instruments remain underdeveloped.

A targeted Pigouvian tax on coal combustion or diesel usage could serve multiple ends, though its implementation is not without complexity. By making carbon-intensive electricity more expensive, the tax would ideally create market incentives for a shift towards cleaner, renewable energy sources. Yet, the pace and scale of this shift would depend on parallel investments in infrastructure and policy support. The revenue generated presents an opportunity to fund climate-resilient infrastructure, extend rural electrification, critical areas where public investment can yield long-term social benefits. Many countries have embraced revenue-neutrality, channelling tax proceeds into household rebates, green subsidies, or social safety nets, or rural electrification. Integrating true social and environmental costs into energy pricing framework can establish the principle of intergenerational equity, though doing so raises difficult questions about short-term affordability and political feasibility. Despite these tensions, a well-designed Pigouvian tax could lay the foundation for a more sustainable and just energy transition. The key lies in careful design, shielding the poor while steering the economy towards low-carbon pathways.



## 4. Policy Recommendations

Energy transition or the coal to clean transition is at the critical juncture of Pakistan's history. On the one hand, the country is dealing with an entrenched coal dependency that delivers short-term energy gains, and on the other, it faces increasing long-term consequences, i.e. environmental degradation, public health crisis, and financial unsustainability. To make this shift meaningful, the following policy recommendations are tailored not only to rectify pricing distortions and carbon externalities, but also to catalyse the systemic transformation in power sector governance and planning.

### Repurpose Coal fired Power Plants into Renewable Energy Hubs

The Ministry of Energy needs to devise a strategic policy framework to repurpose existing coal-fired power plants into renewable energy hubs. These sites are already equipped with grid infrastructure, land rights, and operational facilities, which can be transformed into host solar PV, wind, or hybrid renewable systems with battery storage. This approach reduces the need for new land acquisition and transmission investments while accelerating clean energy deployment. Targeting older or financially stressed plants, particularly those dependent on imported coal, can also reduce fiscal pressures and foreign exchange burdens.

To enable this transition, the policy must be backed by financial incentives, including concessional financing, tax rebates, and transition grants for retrofitting and workforce reskilling.

A clear regulatory roadmap should guide utilities and independent power producers in phasing out coal while integrating renewables. Repurposing coal plants into renewable hubs not only aligns with Pakistan's decarbonization goals but also offers a practical path towards a resilient, and future-ready energy infrastructure.

### Introduce a Targeted Carbon Tax on Coal-Based Power Generation

There should be a differentiated carbon pricing structure that captures the true social cost of coal combustion. A Pigouvian tax, calculated to reflect real-world damages, can serve as a corrective mechanism. For instance, levying PKR 17.07/kWh on local coal (e.g. Sahiwal) versus PKR 37.73/kWh on imported coal (e.g. Engro Thar) recognizes the uneven environmental and transport-related burdens.

### Establish a Cost-Reflective Dispatch Framework

The government should develop a cost-reflective dispatch mechanism that embeds the shadow price of carbon and other externalities such as air pollution and public health damage into NTDC's economic merit order dispatch criteria. This shift is essential to move away from artificially cheap coal generation and toward a more accurate representation of societal costs in power sector planning. To enable this, a robust regulatory framework under NEPRA should be instituted, mandating that external costs are factored into dispatch decisions.

### Ensure Revenue Neutrality Through Climate-Aligned Redistribution

There is a dilemma that carbon taxes can be regressive, but they don't have to be. By redirecting tax revenues into renewable energy deployment, rural microgrids, and climate-adaptive infrastructure, the government can turn a fiscal tool into a developmental lever. To preserve public trust and mitigate inequality, direct transfers or electricity bill rebates should cushion lower-income households. When well-designed, carbon pricing becomes not a penalty, but a platform for inclusive growth.

## Align Carbon Pricing with IMF's Resilience and Sustainability Facility (RSF)

Pakistan has a rare window of opportunity: leverage the IMF's RSF not just for debt relief but as a springboard for policy credibility. Committing to phased carbon pricing under RSF terms can unlock concessional finance, support technical reforms, and signal long-term climate ambition. This is not simply about funding, it's about anchoring investor confidence and accelerating policy convergence with global low-carbon norms.

## Build an Institutional Capacity for Monitoring, Reporting, and Verification (MRV)

Transparent as well as real-time tracking of carbon emissions is non-negotiable. Deploying digital technologies like satellite-based monitoring, plant-level smart meters, and blockchain-enabled data systems will strengthen Pakistan's emissions accountability. In tandem, regulatory agencies need better resources and autonomy.

## Strategic & Gradual Phase-Out of Fossil Fuel Subsidies

Energy subsidies have long distorted market signals. Transitioning these subsidies from fossil fuels to clean technologies must be done gradually with transparency and stakeholder consultations. Cushioning vulnerable populations through targeted tariffs and social protection mechanisms will be essential. This is as much a political challenge as a technical one, but the rewards are immense which include economic efficiency, fiscal space, and environmental resilience.

## Laying Groundwork for Carbon Market Readiness

Carbon markets offer flexibility where carbon taxes impose rigidity. Pakistan should operationalize its 2023 Policy Guidelines on carbon trading and begin groundwork for a domestic Emissions Trading System (ETS). In parallel, NEPRA must adopt a cost-reflective dispatch policy, integrating shadow prices of emissions into grid planning. When the true cost of air pollution and carbon is embedded into dispatch order, clean energy competitiveness will speak for itself.

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