

COAL TO CLEAN CREDIT INITIATIVE

**A CASE FOR EARLY RETIREMENT OF COAL POWER PLANT
USING THE VM0052 METHODOLOGY AND ESTIMATION
OF THE CARBON CREDIT REVENUE**

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Sustainable Development Policy Institute

Table of Contents

Executive Summary	7
1. Introduction	10
1.1. Significance for Pakistan	11
1.2. Objective of the Study	12
2. VM0052 Methodology: Understanding the Eligibility Requirements	14
3. The Case Study of Sahiwal Coal Power Plant	17
3.1 Overview of the Financial and Operational Performance	17
3.2. Eligibility Analysis for Sahiwal Coal Power Plant	19
4. Methodology for Estimating Emission Reductions and Removals	24
4.1. Emissions Analysis	24
4.2. Uncertainty Assessment	28
5. Carbon Credit Revenue Estimation for Sahiwal Coal Plant	30
5.1. Emission Factor and Annual Electricity Generation for Sahiwal CFPP	30
5.2. Total CO ₂ Emissions Avoided Per Year	30
5.3. Annual Revenue from Carbon Credits	30
5.4. The Cost Savings	31
6. Conclusion and Policy Recommendations	33
6.1. Conclusion	33
6.2. Policy Recommendations	33

Executive Summary

EXECUTIVE SUMMARY

This case study is built on the accelerated retirement of coal-fired power plant in Pakistan, focusing on the Sahiwal Coal Power Plant as an eligible case under the VM0052 methodology developed by Verra. The VM0052 methodology, central to the Coal to Clean Credit Initiative (CCCI), facilitates the early retirement of inefficient, high-emission coal plants and their replacement with renewable energy sources. This methodology is embedded within a Just Transition Plan which integrates the social impacts on the community in the framework so that the workers and communities impacted by the transition away from coal are not left behind.

For Pakistan, this approach presents a unique opportunity to decarbonize its power sector because it addresses the fiscal inefficiencies, especially those associated with underutilized coal plants such as Sahiwal. The growing reliance on imported coal, combined with stagnant demand, has made plants like Sahiwal increasingly uneconomical and unsustainable. The Sahiwal Coal Power Plant serves as an ideal case for evaluating the effectiveness of accelerated retirement schemes that can drive both sustainability and economic resilience in Pakistan.

The Sahiwal plant is currently operating under a long-term Power Purchase Agreement (PPA) with the Central Power Purchasing Agency Guarantee (CPPA-G), and it qualifies for accelerated retirement based on criteria set forth in the VM0052 methodology. The criteria include financial viability, historical performance, and the commitment to replacing coal capacity with renewable energy. This process is aligned with Pakistan's climate commitments, including decarbonization targets and the ongoing development of the Long-Term Low Emission Development Strategy (LT-LEDS).

By implementing the VM0052 methodology, Pakistan can transition from its reliance on fossil fuels to a cleaner and more sustainable energy future. The transition would be further supported by the Just Transition measures, which involve community engagement and worker retraining to ensure that the shift to renewable energy benefits everyone, particularly those most affected by the transition.

This initiative not only supports Pakistan's climate goals but also generates significant financial returns through carbon credit sales. The expected annual carbon revenue is USD 60.90 million, and over 20 years, the total revenue generated could amount to USD 1.22 billion. This is an economically feasible way that ensure the bankability of transition while following the principles of just transition.

In FY2024, the Sahiwal Coal Power Plant operated at a high cost of PKR 168.82 billion to generate 2,075 GWh, with capacity charges alone accounting for over 70% of this expense. The resulting levelized cost of PKR 81.36/kWh far exceeded the national average of PKR 27/kWh, indicating the economic inefficiency of underutilized coal assets. Accelerated retirement of such plants could ease pressure on tariffs, while carbon credit revenues under mechanisms like VM0052 offer a pathway to recover costs and support climate objectives.

To realize the potential of VM0052 in Pakistan, a coordinated set of actions is essential. This includes integrating coal retirement and carbon market mechanisms into national energy planning, particularly the IGCEP, by adopting a dynamic decarbonization model that incorporates carbon finance. A fully funded Just Transition Plan is also highly significant for labor reskilling and economic diversification with support from concessional climate finance. A dedicated task force should be established to ensure project-level eligibility, particularly for assets like Sahiwal. Moreover, Pakistan must strengthen its international climate credibility by submitting its LT-LEDS and updating its NDCs with firm commitments on coal phase-out and renewable integration.

1

Introduction

1. INTRODUCTION

Pakistan stands at a critical juncture in addressing its compounded 3E crises: a fiscally strained economy, an inefficient and overextended energy sector, and mounting environmental vulnerabilities. The structural mismatch between installed generation capacity and industrial demand has led to exorbitant capacity payments and a deepening circular debt crisis. At the same time, Pakistan remains highly exposed to climate-induced disasters, that accentuates economic instability and hinders sustainable development. In this context, the country's energy transition imperative must be both economically rational and environmentally credible. The recent withdrawal of the United States from multilateral climate finance initiatives like the Just Energy Transition Partnerships (JETPs) and the Paris Agreement underscores the waning viability of grant-based energy transition models¹. This shift necessitates a pivot to market-based approaches that mobilize private finance and align climate action with fiscal prudence.

One such instrument is the Coal to Clean Credit Initiative (CCCI), operationalized through the Verra-approved VM0052 methodology, which offers a results-based framework for accelerating the retirement of coal-fired power plants (CFPPs). Unlike traditional energy transition models that focus on prospective clean energy deployment, VM0052 incentivizes the decommissioning of existing high-emission assets by enabling the generation of Verified Carbon Units (VCUs) tied to quantified emission reductions. This approach integrates energy system decarbonization with economic viability and social equity—making it highly significant for Pakistan, where coal plants like Sahiwal² represent not just stranded carbon assets but also stranded financial burdens. VM0052 is not merely a carbon accounting tool; it is a strategic enabler for transforming fiscal liabilities into climate assets, offering Pakistan a pathway toward a market-aligned, socially just, and climate-resilient energy future.

The VM0052 methodology³, developed under the Coal to Clean Credit Initiative (CCCI)⁴ led by the Rockefeller Foundation in collaboration with South Pole and Verra, offers a robust framework to quantify greenhouse gas (GHG) emission reductions resulting from the early retirement of coal-fired power plants (CFPPs), paired with renewable energy deployment and a just transition strategy. Recognizing the socio-economic and environmental imperatives of phasing out coal, the methodology integrates emissions accounting with stringent safeguards to ensure that impacted workers, communities, and energy systems are not left behind in the decarbonization process.

At its core, VM0052 incentivizes accelerated CFPP decommissioning by allowing project proponents to generate Verified Carbon Units (VCUs) for the emissions avoided between a project's early shutdown date and the plant's baseline retirement date. The methodology requires that at least 10% of the retired plant's capacity be replaced by renewable electricity at project inception, increasing to a minimum of 40% within the first crediting period. The replacement of energy must originate from clearly defined renewable sources (e.g., solar, wind, hydro, geothermal), and must be supported by a publicly disclosed pairing plan.

1 https://www.esgdrive.com/news/us-exits-climate-finance-initiative-jetp/741942/?utm_source

2 https://www.bu.edu/gdp/files/2023/03/GCI_WP_030_CLARK_FIN.pdf

3 <https://verra.org/new-verra-methodology-supports-coal-phase-out-and-just-energy-transition/>

4 <https://www.rockefellerfoundation.org/initiatives/coal-to-clean-credits/>

Crucially, VM0052 is applicable only where there is a commitment to a fossil-free energy future: project eligibility is contingent upon host governments and utilities having no plans to build new CFPPs or expand existing ones. It demands full integration with the Just Transition Requirements (VMD0061) to ensure that coal phase-out plans address employment, retraining, environmental remediation, and community engagement.

This methodology is a cornerstone in operationalizing Article 6 of the Paris Agreement, enabling countries and utilities to pursue climate goals while maintaining energy security and social equity. It aims to catalyze credible coal-to-clean transitions by aligning emission accounting, economic viability, and social responsibility in one coherent mechanism.

1.1. Significance for Pakistan

The VM0052 methodology under the Coal to Clean Credit Initiative (CCCI) offers Pakistan a timely and transformative tool to rationalize its power sector, which is currently marked by overcapacity, financial inefficiencies, and climate vulnerabilities⁵. At a moment when Pakistan's power planning model—embodied by the Indicative Generation Capacity Expansion Plan (IGCEP)—is attempting to pivot from indiscriminate expansion to selective exclusion, VM0052 enables a far more strategic approach: instead of merely not building new plants, it facilitates the economic and just decommissioning of existing high-cost, underutilized coal-fired power plants (CFPPs). This is critical given that many plants like Sahiwal and China Hub, though technically sound, are fiscally and environmentally misaligned with Pakistan's evolving macroeconomic realities and climate commitments.

For Pakistan, which faces ballooning capacity payments and stagnant demand, VM0052 presents a dual opportunity: decarbonization with fiscal relief. By quantifying and monetizing avoided emissions through high-integrity carbon credits, the methodology creates financial headroom to retire costly CFPPs before their expected end-of-life, redirecting funds toward renewable energy and industrial electrification. This aligns neatly with the tenet that “Thou Shalt Not Expand Electricity Supply Without Industrial Demand,” especially since much of Pakistan's installed generation is currently idle, awaiting a productive demand base that has yet to materialize. VM0052 allows Pakistan to pivot from building megawatts to retiring stranded assets—financially, socially, and environmentally.

Moreover, the methodology's embedded requirement for a comprehensive Just Transition Plan ensures that early retirements do not come at the expense of communities and workers. This is particularly relevant in Pakistan, where coal plants are often located in socioeconomically vulnerable regions. The social license for energy transition depends not only on technical feasibility but also on perceived fairness. VM0052, when coupled with Verra's VMD0061 Just Transition requirements, guarantees that retirement decisions are accompanied by stakeholder engagement, retraining, and local reinvestment. It gives Pakistan the institutional architecture to pursue not just an energy transition, but a just and inclusive one.

Finally, VM0052 enables Pakistan to future-proof its energy policy against international climate policies such as the EU's Carbon Border Adjustment Mechanism (CBAM). By integrating early retirement with renewable replacement and carbon crediting, the methodology transforms what would otherwise be a stranded liability into a tradable climate asset. In doing so, it invites concessional climate finance, aligns with

⁵ <https://www.thenews.com.pk/print/1274985-planning-for-power>

decarbonization targets under the Paris Agreement, and strengthens the competitiveness of Pakistan's export industries in a carbon-constrained global economy. To fully realize this potential, Pakistan must embed VM0052-style financial modeling and carbon cost internalization within the IGCEP framework—transforming it from a static generation plan into a dynamic decarbonization roadmap.

1.2. Objective of the Study

This policy brief provides a guide for early retirement of coal power plant using the recently approved methodology by Verra - VM0052 "ACCELERATED RETIREMENT OF COAL-FIRED POWER PLANTS USING A JUST TRANSITION" developed under the Coal to Clean Credit Initiative (CCCI). The objectives of this brief are as follows

- I. To explore the policy options of early retirement for Pakistan
- II. To conduct eligibility analysis for 1320 MWs Sahiwal Coal Power Plant in Pakistan for early retirement under VM0052 methodology of Verra.
- III. To chart a policy action for long term decarbonization and early retirement plan for Pakistan.

2.

VM0052

Methodology:
Understanding
the Eligibility
Requirements

2. VM0052 METHODOLOGY: UNDERSTANDING THE ELIGIBILITY REQUIREMENTS

The VM0052 methodology for the accelerated retirement of coal-fired power plants (CFPPs) hinges on strict eligibility and integrity criteria across three core domains: Just Transition, CFPP Retirement, and Paired Renewable Electricity. These conditions ensure that emissions reductions are credible, socially responsible, and aligned with national and global climate goals.

Under the Just Transition pillar, project proponents must present a comprehensive plan aligned with the Verra Module VMD0061 at the time of project validation. Crucially, this plan must be independently funded—revenues from Verified Carbon Units (VCUs) cannot be used—to ensure that social protections for affected workers and communities are safeguarded irrespective of credit sales.

The CFPP Retirement eligibility conditions are designed to prevent perverse incentives and greenwashing. Eligible CFPPs must have been constructed prior to 31 December 2021 and remain grid-connected. Long-term power purchase agreements (PPAs) must have been executed before 31 December 2023. The plant must demonstrate three years of positive net income and fair asset valuation per IFRS standards. Furthermore, the project must not compromise energy security, as confirmed by an official letter attesting that the retirement does not negatively affect grid stability, electricity access, or pricing. Projects owned by state utilities or independent power producers (IPPs) must also commit publicly to no future coal expansion. Importantly, only countries with power sector decarbonization or renewable energy targets in their Nationally Determined Contributions (NDCs), and those that have submitted Long-Term Low Emissions Development Strategies (LT-LEDS), are eligible. Plants that have been repurposed to burn fossil fuels, are mine-mouth facilities, or are captive plants are explicitly excluded.

On the Paired Renewable Electricity front, a validated renewable energy pairing plan is mandatory. This plan must demonstrate that at least 10% of the CFPP's capacity will be replaced by renewable electricity at project start, increasing to 40% by the end of the first crediting period. Only specific technologies are eligible, including solar, wind, small-scale hydro, geothermal, tidal/wave, biogas, and biomass (subject to compliance with ACM0006). Each renewable facility must be named in the plan, with full details on type, capacity, location, and commercial operation date.

These criteria jointly ensure that early CFPP retirement is not only environmentally sound but also economically viable and socially just—thereby setting a high bar for carbon finance integrity under the VM0052 framework.

Table 1: Eligibility Criteria for VM0052 Methodology

Category	Criteria Description
Just Transition	1. A Just Transition plan (per VMD0061) must be available at validation. 2. The plan must be fully funded from sources other than VCU revenues.
CFPP	3. CFPP construction began before 31 December 2021. 4. CFPP is connected to the grid. 5. In regulated markets: owned by regulated utility or IPP. 6. Long-term (≥ 20 years) PPA executed before 31 Dec 2023: a) Regulated market: with system operator/utility. b) Deregulated market: with eligible Load-Serving Entity (LSE). 7. At validation and retirement date: positive net income (3 years) and positive fair value as per the International Financial Reporting Standards (IFRS). 8. State-owned utility + host country must commit to no new coal or capacity increases.
Retirement	9. IPP must commit to no new or expanded coal capacity globally. 10. Official letter confirms retirement has no material negative effects on prices, access, grid stability, or supply. 11. Host country's NDC includes: a) Power sector decarbonization target, or b) Renewable energy target. 12. Host country has submitted LT-LEDS or published a relevant decarbonization strategy. Not Eligible if: 13. CFPP repurposed to burn fossil fuels. 14. It is a mine-mouth plant. 15. It is a captive power plant.
Paired Renewable Electricity	16. Renewable pairing plan at validation: a) Exports to grid. b) $\geq 10\%$ of CFPP capacity at project start. c) $\geq 40\%$ by end of first crediting period. 17. Plan lists name, type, capacity, location, and commercial operation date for each paired renewable plant. 18. Acceptable renewable sources: a) Solar (with/without BESS), b) Wind, c) Hydro (≤ 15 MW), d) Geothermal, e) Tidal/wave, f) Biogas, g) Biomass per ACM0006.

3.

The Case Study of Sahiwal Coal Power Plant

3. THE CASE STUDY OF SAHIWAL COAL POWER PLANT

The Sahiwal Coal Power Plant, operated by Huaneng Shandong Ruyi (Pakistan) Energy (Private) Limited (HSR), stands as one of Pakistan's largest and most strategic independent power producers (IPPs) under the China-Pakistan Economic Corridor (CPEC) framework. Located in Qadirabad, District Sahiwal, Punjab, the plant has a gross capacity of 1,320 megawatts (MW) consisting of two 660 MW units, with a net deliverable capacity of 1,243.52 MW. The project, commissioned on October 28, 2017, is not a mine mouth project. The plant is coal-fired and relies on imported coal, with a revised procurement agreement signed in December 2023 with Awan Trading Company (Pvt.) Ltd., replacing China Huaneng Fuel Company.

3.1 Overview of the Financial and Operational Performance

Power Purchase Agreement and Regulatory Terms

The plant operates under a long-term Power Purchase Agreement (PPA) with the Central Power Purchasing Agency Guarantee (CPPA-G) for 30 years, which guarantees a 50% offtake and assures a sovereign guarantee from the Government of Pakistan under the Implementation Agreement⁶. The agreement stipulates performance benchmarks of 85% availability and 39.75% thermal efficiency, both of which the plant has consistently met. The tariff determined by NEPRA for the project includes a levelized rate of US¢ 7.8457 per kilowatt-hour (kWh), with the current applicable rate being PKR 11.80/kWh⁷ for capacity payments and PKR 17.81/kWh⁸ for energy charges. The Internal Rate of Return (IRR) allowed by the regulator is 27.2% for imported coal and 29.5% for local coal usage, although the plant has yet to diversify its fuel mix.

Ownership and Corporate Governance

HSR is a wholly-owned subsidiary of Huaneng Shandong Ruyi (Hong Kong) Energy Limited, which is jointly owned by Huaneng Shandong Power Generation Company Limited⁹ and Jining Chengtuo Holding Group Company Limited¹⁰. The ultimate parent, China Huaneng Group Company Limited, is a state-owned conglomerate with vast experience in the energy sector, including coal, renewables, and infrastructure. The Board of Directors comprises five members, including representatives from both Chinese sponsors. Mr. Li Xin, the Chairman and CEO, leads the management and has been associated with

⁶ [https://nepra.org.pk/tariff/Tariff/IPPs/Huaneng%20Shandong%20Ruyi%20\(Pakistan\)%20Energy%20\(Private\)%20Limited/TRF-308%20HUANENG%20UPFRONT%20COAL%20DETERMINATION%2031-03-2015%204385-87.pdf](https://nepra.org.pk/tariff/Tariff/IPPs/Huaneng%20Shandong%20Ruyi%20(Pakistan)%20Energy%20(Private)%20Limited/TRF-308%20HUANENG%20UPFRONT%20COAL%20DETERMINATION%2031-03-2015%204385-87.pdf)

⁷ [https://nepra.org.pk/tariff/Tariff/Notifications/2025/04%20Apr/SRO%20397\(I\)-2025%20Dated%2020-03-2025.pdf](https://nepra.org.pk/tariff/Tariff/Notifications/2025/04%20Apr/SRO%20397(I)-2025%20Dated%2020-03-2025.pdf)

⁸ [https://nepra.org.pk/tariff/Tariff/IPPs/Huaneng%20Shandong%20Ruyi%20\(Pakistan\)%20Energy%20\(Private\)%20Limited/TRF-308%20HSRPEL%20FPA%20MAR-2025%2030-04-2025%204312-16.pdf](https://nepra.org.pk/tariff/Tariff/IPPs/Huaneng%20Shandong%20Ruyi%20(Pakistan)%20Energy%20(Private)%20Limited/TRF-308%20HSRPEL%20FPA%20MAR-2025%2030-04-2025%204312-16.pdf)

⁹ <https://www.chng.com.cn/en/companyoverview.html>

¹⁰ <https://www.verif.com/en/company/Jining-Chengtuo-Holding-Group-Co.-Ltd.-6b0611d7d3447ebb2e656790c3d7273bbabb461074cc16bf086d5db5214d24e8/>

the company for over five years. Governance is streamlined with a flat organizational structure, common among IPPs, with the operational functions outsourced to Shandong Huatai Electric Operations & Maintenance (Pvt.) Ltd¹¹.

Financial Performance and Indicators

The financial performance of the company has shown resilience, with revenues reaching PKR 202 billion in 2023, a modest growth from PKR 194 billion in 2022. The net profit for 2023 stood at PKR 43.75 billion, indicating a net margin of 21.6%. The plant's free cash flows from operations also improved significantly, reaching PKR 108 billion. However, the company faces acute financial stress due to circular debt, with receivables from CPPA-G ballooning to PKR 125.94 billion in 2023. This liquidity strain has forced HSR to increasingly rely on short-term borrowings, which reached PKR 40.23 billion by year-end. Despite this, the company has managed to maintain a strong debt servicing profile, with 43% of its original project debt of USD 1.41 billion already repaid. The total project cost stood at USD 1.912 billion¹², financed through an 80:20 debt-equity structure¹³.

Table 2: Financial Performance of the Plant(Million Rs)

Metric	2023	2022	2021
Revenue	202,181	194,171	147,089
Net Profit	43,751	20,970	25,619
Gross Profit Margin	49.2%	24.6%	28.1%
Net Profit Margin	21.6%	10.8%	17.4%
Free Cash Flow from Ops	108,084	56,274	48,641
Total Assets	561,721	493,436	379,019
Total Borrowings	286,431	262,186	221,493
Equity	179,234	135,483	114,512
Debt-to-Equity Ratio	61.5%	65.9%	65.9%

Operational Performance and Dispatch Profile

Operationally, the plant's output in 2023 declined to 2,090 GWh from 4,855 GWh in 2022, primarily due to reduced dispatch by NTDC in light of cheaper electricity sources. Nevertheless, the plant climbed the NTDC merit order from 30th in July 2023 to 20th in July 2024, largely due to cost optimization, with its specific cost decreasing from PKR 28.87/kWh to PKR 17.15/kWh, currently the energy cost is PKR 17.81/kWh. The plant has consistently maintained performance benchmarks of 85% availability and 39.75%

¹¹ https://www.pacra.com/summary_report/RR_2426_10428_22-Jul-22.pdf

¹² <https://cpec.gov.pk/project-details/2>

¹³ https://www.pacra.com/summary_report/RR_2426_13294_19-Jul-24.pdf

efficiency as required under its PPA.

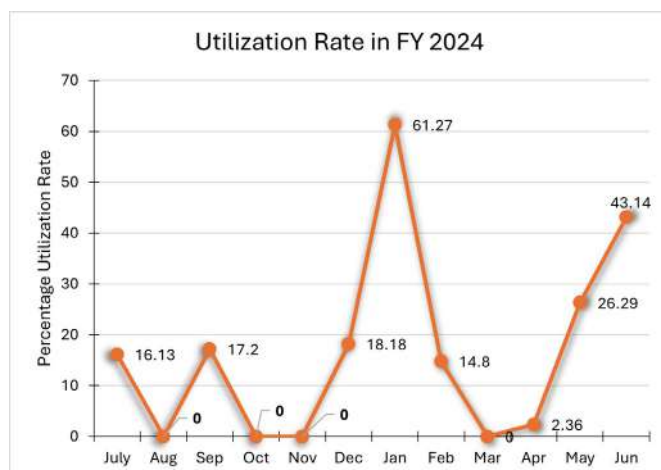


Figure 1- Utilization Rate of the Plant in FY2024

The monthly utilization rate data you provided for the power plant in FY24 paints a telling picture of severe underutilization and inconsistent dispatch:

With multiple months showing a 0% utilization rate (August, October, November, and March), the plant remained idle for a significant portion of the year. This suggests that the plant is operating well below economically viable levels and is possibly incurring capacity payments without generating electricity.

Utilization peaked in January (61.27%) and June (43.14%), likely due to seasonal demand. However, these occasional spikes do not justify the continued operation of such a capital-intensive asset when the annual average is likely far below 30%.

High capital and fuel costs—especially for imported coal—make such plants financially burdensome when not dispatched regularly. Their role becomes increasingly questionable in a context where cheaper renewables and low-demand growth dominate the landscape.

The utilization trend also shows that this power plant is not a critical power plant in terms of system stability, electricity access and overall socioeconomic situation of the country.

3.2. Eligibility Analysis for Sahiwal Coal Power Plant

The Sahiwal Coal Power Plant, a 1,320 MW grid-connected independent power producer (IPP) in Punjab, Pakistan, meets several key eligibility criteria under the emerging methodologies for coal phase-out and carbon financing, such as Verra’s VMD0061. Originally commissioned in October 2017 with construction initiated well before the 31 December 2021 threshold, the plant qualifies under the foundational criteria for coal-fired power plant (CFPP) retirement. Operating within Pakistan’s regulated electricity market and under a 30-year Power Purchase Agreement (PPA) signed with the Central Power Purchasing Agency Guarantee (CPPA-G), the facility benefits from sovereign guarantees and receives both capacity and energy payments, meeting the requirements for long-term regulated PPAs under this framework.

To qualify under the Just Transition criteria, however, Pakistan must transition from its current Indicative Generation Capacity Expansion Plan (IGCEP) to a comprehensive Just Transition Plan, as prescribed by the VMD0061 methodology. This plan must be fully funded from sources other than Verified Carbon Unit (VCU) revenues. Funding avenues such as the Asian Development Bank’s Energy Transition Mechanism (ETM) or Just Energy

Transition Partnerships (JETPs) can be leveraged to meet this requirement. Furthermore, the plant has demonstrated sustained positive net income over the past three years, with financial disclosures aligning with International Financial Reporting Standards (IFRS), thereby satisfying financial viability benchmarks at the point of validation and projected retirement.

While the plant is not state-owned and its removal is unlikely to impact grid reliability significantly, a critical limitation lies in the parent company's diversified portfolio, which includes both fossil fuel and renewable energy investments globally. To overcome this barrier, one viable solution may be the acquisition of the plant by the Government of Pakistan, thereby aligning the ownership structure with the methodology's eligibility clause that discourages ongoing fossil fuel expansion by participating entities.

In terms of power system impact, the plant's position in the NTDC merit order (20th as of July 2024) and the declining dispatch due to preference for cheaper sources indicate that its retirement would likely have minimal negative implications¹⁴ for grid stability or power prices. Nonetheless, a formal governmental assessment would be required to certify the absence of adverse system-wide effects, as stipulated in the methodology.

Pakistan's forthcoming Nationally Determined Contributions (NDCs) are expected to include a clear commitment to power sector decarbonization, and the Ministry of Planning, Development and Special Initiatives is currently formulating a Long-Term Low Emission Development Strategy (LT-LEDS). These developments strengthen the country's alignment with eligibility criteria related to national climate planning and long-term decarbonization strategies.

Regarding the renewable pairing requirements, the repurposing of the Sahiwal site into a solar park is deemed feasible. This plan could include phased capacity additions with at least 10% of the coal plant's original capacity replaced at the start of the crediting period, and 40% by its conclusion. The eligible renewable energy types include solar (with or without battery storage), and feasibility assessments can specify plant details such as location, type, capacity, and expected commercial operation dates.

Finally, the Sahiwal Coal Power Plant does not fall under any exclusionary categories—it is not a captive power plant, a mine-mouth plant, nor has it been repurposed to burn other fossil fuels. Taken together, these factors indicate that, with appropriate institutional reforms and ownership restructuring, the plant holds significant potential for eligibility under coal-to-clean transition methodologies¹⁵, and could become a pilot case for Pakistan's entry into carbon finance-driven coal retirement pathways.

¹⁴ https://www.researchgate.net/publication/369901944_Pitfalls_of_Restoring_Energy_Security_with_Coal_Power_Plants_in_Pakistan

¹⁵ <https://sdpi.org/assets/lib/uploads/Report%20-%20Transitioning%20away%20from%20coal.pdf>

Table 3: Eligibility Analysis for the Sahiwal Coal Power Plant

Category	Criteria Description	Eligibility Analysis
Just Transition	1. A Just Transition plan (per VMD006116) must be available at validation.	Pakistan must replace its Indicative Generation Capacity Expansion Plan (IGCEP) to Just Transition Plan.
	2. The plan must be fully funded from sources other than VCU revenues.	In this context, Just Energy Transition Partnerships (JETPs) or Asian Development Bank (ADB)'s Energy Transition Mechanism (ETM) can be employed.
CFPP Retirement	3. CFPP construction began before 31 December 2021.	Yes, the construction was completed in 2017.
	4. CFPP is connected to the grid.	Yes. The Sahiwal Coal Power Plant is connected to the National Grid.
	5. In regulated markets: owned by regulated utility or IPP.	Yes. Pakistan's Power market is a regulated market and the aforementioned power plant is an independent power pant (IPP).
	6. Long-term (≥ 20 years) PPA executed before 31 Dec 2023:	The Power Purchase Agreement (PPA) for the Sahiwal Coal Power Plant is for a duration of 30 years, starting from the Commercial Operation Date (COD), which is 28th October 2017.
	a) Regulated market: with system operator/utility.	This long-term PPA was signed with the Central Power Purchasing Agency Guarantee Limited (CPPA-G) and includes a sovereign guarantee by the Government of Pakistan through the Implementation Agreement. It also ensures:
	b) Deregulated market: with eligible Load-Serving Entity (LSE).	Guaranteed off-take of at least 50% of the plant's net capacity Capacity payments (subject to meeting 85% availability) Energy payments (based on actual dispatch and fuel use).
	7. At validation and retirement date: positive net income (3 years) and positive fair value as per the International Financial Reporting Standards (IFRS).	As per the financial statistics in table 2, the plant has net positive income.
	8. State-owned utility + host country must commit to no new coal or capacity increases.	It is not a state owned entity. As per the utilization rates the power plant is not critical for the stability of the power system.
	9. IPP must commit to no new or expanded coal capacity globally.	The SPV has a broad multi purpose portfolio of investments in fossil fuel and renewable energy power plants globally. One possible solution can be the purchase of this power plant by the government of Pakistan and then employment of aforementioned methodology.
	10. Official letter confirms retirement has no material negative effects on prices, access, grid stability, or supply.	Depends on the government policy
	11. Host country's NDC includes: a) Power sector decarbonization target, or b) Renewable energy target.	The upcoming NDCs of Pakistan will include the decarbonization of power sector ambition/commitment in the document.
	12. Host country has submitted LT-LEDS or published a relevant decarbonization strategy.	The Ministry of Planning Development and Special Initiatives (MoPDSI) is working on the Long Term - Low Emission Development Strategy.
	Not Eligible if:	The power plant is not repurposed, neither a mine-mouth nor captive power plant.
	13. CFPP repurposed to burn fossil fuels.	
	14. It is a mine-mouth plant.	
15. It is a captive power plant.		

Paired Renewable	16. Renewable pairing plan at validation: a) Exports to grid. b) $\geq 10\%$ of CFPP capacity at project start. c) $\geq 40\%$ by end of first crediting period.	The repurposing of the power plant to Solar park is feasible.
Electricity	17. Plan lists name, type, capacity, location, and commercial operation date for each paired renewable plant.	The repurposing of the power plant to Solar park is feasible.
	18. Acceptable renewable sources: a) Solar (with/without BESS), b) Wind, c) Hydro (≤ 15 MW), d) Geothermal, e) Tidal/wave, f) Biogas, g) Biomass per ACM0006.	The repurposing of the power plant to Solar park is feasible.

4.

**Methodology
for Estimating
Emission
Reductions and
Removals**

4. METHODOLOGY FOR ESTIMATING EMISSION REDUCTIONS AND REMOVALS

Quantifying reductions and removals are not only a technical necessity but it's a measure of the success of accelerated coal-fired power plant (CFPP) retirements. This section discusses the methodology that can be used to calculate greenhouse gas (GHG) emissions reductions that stem from the early shutdown of CFPPs, alongside the shift toward renewable energy sources that partially or fully replace the lost generation capacity. But it's not just about emissions; it's about comprehensively understanding the interplay of baseline emissions, project emissions, and leakage emissions, all of which are precisely calculated using a set of rigorous, interconnected equations. These formulas serve to accurately capture the full impact of the transition to cleaner energy, quantifying not just the carbon footprint, but the very essence of a nation's decarbonization journey.

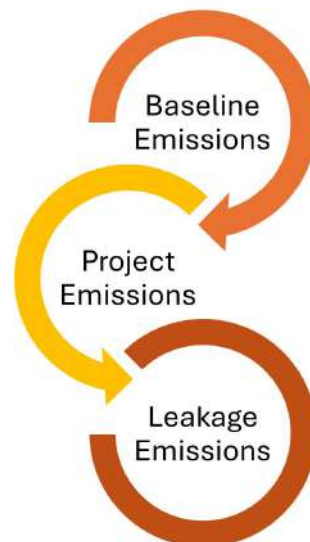


Figure 2- Typology of emissions

The real challenge, however, is not just about cutting emissions, it's about doing so responsibly. The Just Transition principle weaves its way through this process, ensuring that the workers, communities, and ecosystems impacted by the retirement of coal plants are not left behind. So, while this methodology sticks to global standards for emission accounting and carbon finance, it also speaks to something larger i.e. the need to keep equity at the centre of climate solutions. The stance is evident that environmental sustainability can and must coexist with economic resilience, forming a future where cleaner energy is the standard, and the people who powered the old systems are empowered to build the new ones.

Emissions Analysis

The following table outlines the key equations for calculating baseline emissions in the context of accelerated CFPP retirement, as specified in the VM0052 methodology. These calculations are essential for quantifying the reductions in GHG emissions due to the decommissioning of coal-fired power plants and their replacement with renewable energy.

Table 4: Methodology for calculating baseline emissions

Equation Description	Formula	Variables and Definitions
Baseline Emissions in Year y	$BE_y = EG_{BL\ CFPPy} \times EF_{BLy}$	<p>BE_y = Baseline emissions in year y (t CO₂)</p> <p>EG_{BL CFPPy} = Baseline net electricity generated by the CFPP and supplied to the grid in year y (MWh)</p> <p>EF_{BLy} = Baseline emission factor for the CFPP in year y (t CO₂/MWh)</p>
Baseline Net Electricity Generated and Supplied	$EG_{BL\ CFPPy} = CAP_{CFPP} \times CUF_{BLy} \times 8760$	<p>EG_{BL CFPPy} = Baseline net electricity generated and supplied</p> <p>CAP_{CFPP} = Net installed generation capacity of the CFPP being retired (MW)</p> <p>CUF_{BLy} = Historical capacity utilization factor of the CFPP (dimensionless)</p> <p>8760 = Number of hours in one year</p>
Capacity Utilization Factor	$CUF_{BLy} = \text{MIN} \left(\text{MIN} \left(\frac{EG_{3Y\ Val}, EG_{3Y\ AR}, EG_{5Y\ Val}, EG_{5Y\ AR}}{CAP_{CFPP} \times T} \right), CUF_{ref} \right)$	<p>EG_{3Y Val} = Net electricity delivered to the grid by the CFPP in the 3-year period preceding validation (MWh)</p> <p>EG_{3Y AR} = Net electricity delivered to the grid by the CFPP in the 3-year period preceding the accelerated retirement date (MWh)</p> <p>EG_{5Y Val} = Net electricity delivered to the grid by the CFPP in the 5-year period preceding validation (MWh)</p> <p>EG_{5Y AR} = Net electricity delivered to the grid by the CFPP in the 5-year period preceding the accelerated retirement date (MWh)</p> <p>CUF_{ref} = Average capacity utilization factor of at least two reference CFPPs.</p> <p>T = Hours in the period selected (3-years: 26,280, 5-years: 43,800)</p>
Average Capacity Utilization Factor	$CUF_{ref} = \frac{EG_{ref}}{CAP_{ref} \times 8760}$	<p>EG_{ref} = Average net electricity generation of at least two reference CFPPs in year y (MWh)</p> <p>CAP_{ref} = Net installed generation capacity at the</p>

		interconnection <u>point</u> of the reference plants (MW)
Baseline Emission Factor	$EF_{BLY} = (FC_C \times NCV_C \times EF_{CO_2,C}) / EG_{CFPP}$	<p>FC_C = Quantity of coal fired in the CFPP (mass unit)</p> <p>NCV_C = Weighted average net calorific value of coal used in the CFPP (GJ/mass unit)</p> <p>EF_{CO₂,C} = CO₂ emission factor of coal used in the CFPP (t CO₂/GJ)</p> <p>EG_{CFPP} = Historical quantity of electricity generated and supplied to the grid by the CFPP (MWh)</p>

The next step is to calculate the project emissions, which are basically the greenhouse gases (GHGs) emitted from renewable energy capacity that is linked with the accelerated retirement of a coal-fired power plant (CFPP). These emissions are calculated based on the operation of renewable power plants paired with the CFPP. The formula to compute project emissions is as follows

$$PE_Y = \sum_i PE_{REi,y}$$

Where

PY_E = Project emissions in year y (in tons of CO_{2e})

$PY_{REi,y}$ = Project emissions from the operation of paired renewable electricity power plant i in year y (in tons of CO_{2e})

The renewable electricity technologies such as solar, wind (on-shore/offshore), tidal, and wave, do not generate emissions during their operation. However, other renewable energy sources, such as geothermal, biomass, and waste-to-energy, may emit GHGs. These emissions need to be quantified according to specific CDM methodologies, including but not limited to the

Landfill Gas - For electricity generation from landfill gas (ACM0001: Flaring or Use of Landfill Gas)

Geothermal and Hydropower - For grid-connected generation from renewable sources (ACM0002: Grid-connected Electricity Generation from Renewable Sources)

Biomass - For biomass-fired power plants (ACM0006: Electricity and Heat Generation from Biomass)

Wastewater Treatment - For wastewater treatment (ACM0014: Treatment of Wastewater)

Waste-to-Energy - For waste-to-energy power plants (ACM0022: Alternative Waste Treatment Processes)

The other type of emissions that needs to be calculated are the leakage emissions, these are the indirect emissions that result from the renewable energy project, such as those from a substitution effect. These emissions are calculated with the following formula

$$LE_Y = \text{MAX} \left[0, \left(EG_{BL,CFPP_Y} - \sum_i EG_{REi,y} \right) \times EF_{CM,Y} \right] + LE_{REi,y}$$

Where

For renewable electricity plants that are paired with a CFPP via a counterfactual pathway,

LE_Y = Leakage emissions in year y (in tons of CO_{2e})

$EG_{REi,y}$ = Net electricity generated and supplied to the grid by the paired renewable electricity power plant i in year y (in MWh)

$EF_{CM,Y}$ = Combined margin emission factor associated with the production of EG_{Grid} in year y (in tons of CO_{2e}/MWh)

$LE_{REi,y}$ = Leakage emissions from paired renewable electricity power plant i in year y (in tons of CO_{2e})

the renewable electricity generation should be accounted for between the operational start date of the renewable project and the baseline scenario's operational start date.

For Estimating Grid Emission Factor ($EF_{CM,Y}$) the weighted average of the operating margin emission factor (EF_{OM}) and the build margin emission factor (EF_{BM}), as follows

This formula accounts for the proportion of emissions from both the operating and build margins, enabling a more accurate estimation of leakage emissions in the grid system.

The calculation for net greenhouse gas (GHG) emission reductions is given by the following formula

$$ER_y = BE_y - PE_y - LE_y$$

where

ER_y= GHG emission reductions in year y (in tons of CO_{2e})

BE_y= Baseline emissions in year y (in tons of CO_{2e})

PE_y = Project emissions in year y (in tons of CO_{2e})

LE_y= Leakage emissions in year y (in tons of CO_{2e})

4.2. Uncertainty Assessment

The primary sources of uncertainty in the emission reduction calculation are linked to the estimation of the electricity that would have been generated by the CFPP and the emission factors associated with both the CFPP and the additional electricity from grid-connected power plants.

To address uncertainty in baseline electricity production, a conservative approach is adopted, which involves underestimating the potential electricity output. This is achieved by considering two reference CFPPs that represent comparable coal operations within the country. The minimum value is then selected from either the dynamic CFPPs or the historical generation data from the retired plant.

The emission factor for the CFPP is based on historical data regarding fuel consumption and electricity generation. These values typically have very low uncertainty, given the established measurement practices in the industry and their direct relation to commercial transactions. Similarly, the Net Calorific Value (NCV) and fuel emission factors (EF) exhibit low uncertainty.

The effective heat rate (the amount of fuel consumed per megawatt-hour produced) for the CFPP is determined during validation and remains fixed throughout the project. This approach is conservative, as it does not account for the natural decrease in efficiency that would likely occur as the plant ages.

Regarding the incremental output from grid-connected power plants, the emission factor is calculated conservatively. This approach includes potential emissions from mothballed coal-fired plants and ensures the use of the operating margin, which tends to yield higher emissions than average or adjusted margins. Additionally, upstream methane leakage associated with power generation is factored in.

For paired renewable electricity plants, the uncertainty is estimated to be below 1%, thanks to the high accuracy of metering and the nature of commercial transactions involved. Project and leakage emissions are generally expected to be either negligible or low, depending on the technology used. While certain parameters, such as those related to methane emissions, may have individual uncertainties, their overall impact on the total emissions is minor.

The overall uncertainty for the emission reduction calculations is estimated to be under 10%, indicating that no adjustments or discounts are necessary to account for quantification uncertainty. Further details on the uncertainty related to the baseline retirement date are addressed in VMD0060.

5.

**Carbon Credit
Revenue**

**Estimation for
Sahiwal Coal
Plant**

5. CARBON CREDIT REVENUE ESTIMATION FOR SAHIWAL COAL PLANT

To estimate the potential revenue from carbon credits for the Sahiwal Coal Plant, this study adopted a systematic approach that is discussed above, in the previous section. The calculations are based on the amount of carbon dioxide (CO₂) emissions avoided through the accelerated retirement of the coal-fired power plant (CFPP), as well as the prevailing carbon credit price.

5.1. Emission Factor and Annual Electricity Generation from Sahiwal CFPP

The emission factor for Sahiwal CFPP is estimated to be 617.25 kg CO₂ per MWh¹⁷, which represents the amount of CO₂ emitted for every megawatt-hour (MWh) of electricity generated. Based on the plant's average annual electricity generation of 3,944,593.33 MWh, the total annual CO₂ emissions avoided by transitioning to cleaner energy sources or through emissions reduction projects is calculated.

5.2. Total CO₂ Emissions Avoided Per Year

Using the estimated emission factor and the plant's annual electricity generation, the

$$EA_{CO_2} = EG_y \times EF_{S.CFPP}$$

total CO₂ emissions avoided each year is calculated as follows

EA_{CO₂} represents the total CO₂ emissions avoided

EG_y represents the annual electricity generation

EF_{S.CFPP} represents the emission factor for Sahiwal CFPP

represents the emission factor for Sahiwal CFPP

As per estimations, the total annual avoided emission are 2,435,866,098.64 kg of CO₂, which is approximately 2.44 million metric tons of CO₂ per year.

$$\begin{aligned} \text{Total Annual Avoided Emission} &= \mathbf{2,435,866,098.64 \text{ kg of CO}_2} \\ &= \mathbf{2.44 \text{ million metric tons of CO}_2 \text{ per year.}} \end{aligned}$$

5.3. Annual Revenue from Carbon Credits

The next step involves estimating the revenue generated from carbon credits, which will be awarded for emissions reductions. Assuming a low bound carbon credit price of USD

$$AR_{CC} = EA_{CO_2} \times CCP$$

25 per metric ton of CO₂, the annual revenue is calculated by multiplying the total CO₂ emissions avoided per year by the carbon credit price:

where

AR_{CC} represents carbon credit Price = USD 25 per ton of CO₂

CCP represents carbon credit Price = USD 25 per ton of CO₂
The annual revenue from carbon credits is estimated to be

USD 60,896,652.50/year = USD 60.90 million per Year

Given the remaining operational life of the Sahiwal Coal Plant is 20 years, the total revenue from carbon credits $TR_Y = AR_{CC} \times OLY$ is estimated as

where

TR_Y represents the revenue generated from CFPP based on its operational life

OLY represents the years of operational life

The total revenue from carbon credits in 20 years of operational life of Sahiwal CFPP is calculated to be around USD 1,217,933,050.00.

The total revenue from carbon credits in **20 years** of operational life of Sahiwal CFPP is calculated to be around

USD 1,217,933,050.00 or USD 1.22 billion in 20 years

5.4. The Cost Savings

In fiscal year 2024, the Sahiwal Coal Power Plant incurred a total operational cost of PKR 168.82 billion for generating 2,075 GWh of electricity. This total comprises an energy charge of PKR 45.63 billion and a significantly higher capacity charge of PKR 123.19 billion (approximately USD 607.2 million). This translated into a levelized cost of PKR 81.36 per kilowatt-hour (kWh) for electricity supplied to consumers, substantially exceeding the national average reference power purchase price of PKR 27 per kWh in the same period.

The disproportionately high capacity charges, which represent payments to ensure plant availability regardless of actual generation, underscore the financial inefficiency of maintaining underutilized coal-fired power assets. Strategically retiring such plants ahead of their projected lifespan could alleviate the fiscal burden on the electricity tariff structure. Furthermore, the cost differential could be partially offset through revenues from carbon credits¹⁷ generated under recognized methodologies such as VM0052, thereby aligning financial rationality with climate mitigation goals.

¹⁷ <https://www.weforum.org/publications/scaling-financing-for-coal-phase-out-in-emerging-economies/>

6.

**Conclusion
and Policy**

Recommendations

6. CONCLUSION AND POLICY RECOMMENDATIONS

6.1. Conclusion

The early retirement of coal-fired power plants in Pakistan, exemplified by the case of the Sahiwal Coal Power Plant, presents a compelling opportunity to simultaneously address the country's economic, energy, and environmental challenges—the so-called 3E crisis. The VM0052 methodology under the Coal to Clean Credit Initiative provides a scientifically rigorous, socially just, and financially viable mechanism to transition away from fossil-intensive energy sources toward cleaner alternatives. Given the high operational and capacity costs of coal plants¹⁸, especially under conditions of underutilization and excess installed capacity, Pakistan can no longer afford to maintain these legacy assets. By leveraging market-based mechanisms such as carbon crediting, Pakistan has a credible pathway to phase out coal without compromising energy security or burdening the public exchequer. The convergence of economic logic, climate obligations, and international market signals makes coal retirement not just an environmental imperative but a strategic national priority.

6.2. Policy Recommendations

- I. To translate the potential of VM0052 into tangible outcomes for Pakistan, a set of comprehensive and coordinated policy actions is needed. First, the government must embed coal retirement and carbon market mechanisms into the mainstream energy planning framework, such as the Indicative Generation Capacity Expansion Plan (IGCEP). This requires moving from a static supply-side planning model to a dynamic decarbonization roadmap that accounts for carbon pricing, capacity payments, and system-level externalities. IGCEP should formally recognize carbon finance as a legitimate revenue stream, enabling a holistic cost-benefit analysis for coal phase-out decisions.
- II. Second, Pakistan must urgently develop a fully articulated, independently funded Just Transition Plan to meet the foundational requirements of VM0052. This plan must go beyond technical retirement schedules and include robust strategies for labor reskilling, economic diversification in coal-dependent regions, and investments in community infrastructure. Given the fiscal limitations of the government, this plan should be financed through concessional climate finance channels such as the Asian Development Bank's Energy Transition Mechanism and future iterations of Just Energy Transition Partnerships, with implementation aligned to Verra's VMD0061 requirements.
- III. Third, a dedicated task force should be established under the Ministry of Climate Change and the Ministry of Energy to coordinate project-level eligibility assessments, renewable pairing plans, and ownership restructuring, particularly for plants like Sahiwal, which currently do not meet all VM0052 conditions due to their parent company's global fossil investments. Public acquisition or stra-

¹⁸ <https://www.sciencedirect.com/science/article/abs/pii/S1040619020301986>

tegic restructuring of such plants can align ownership profiles with eligibility criteria, unlocking access to international carbon markets.

- IV. Fourth, to ensure systemic credibility and international market access, Pakistan must accelerate the submission of its Long-Term Low Emissions Development Strategy (LT-LEDS) and update its Nationally Determined Contributions (NDCs) to include explicit commitments on coal phase-out and renewable integration. These documents are not just formalities but critical validation instruments for eligibility under VM0052 and for signaling readiness to climate investors and carbon credit buyers globally.
- V. Finally, regulatory reforms should facilitate the repurposing of decommissioned coal sites for renewable energy production. Fast-tracking approvals for solar and wind installations, ensuring grid access for these projects, and integrating them into the NTDC's dispatch priority list will be essential. Financial instruments such as green bonds and blended finance facilities should also be designed to support the capital expenditures needed for renewable deployment, especially in sites like Sahiwal.



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