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Accelerating the Coal-to-Clean Transition

Five Global Case Studies of Scalable, Just and Profitable Near-Term Transactions, and the Role for Philanthropy

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Key Findings

Renewable energy asset profit margins can be more than enough to pay for coal plant closure costs while still generating a profit for the power facility's operator.

Investing in a coal-to-clean transition transaction, rather than a pure decommissioning of coal, presents a compelling value proposition.

Philanthropy can play a catalytic role by funding local transition facilitation teams that carry out financial analysis and diligence of a specific coal-to-clean project (rather than funding the entire transaction). This reduces transaction development risks while leveraging philanthropic funds effectively.

Only 10% of the world's existing coal power capacity is slated for decommissioning by 2030. More coal decommissioning transactions can be closed in the next three to five years. Governments, investors and philanthropic organisations should invest effort to identify these opportunities.

Executive Summary

The decarbonisation of electricity in emerging market economies can be achieved through a market-based, economically viable transaction to accelerate the transition of generation from coal to clean energy, plus storage in many instances. Coal generation assets can be ramped down and decommissioned, while renewables and storage assets are invested in to replace them. This report analyses five specific opportunities around the world where a coal-to-clean transaction could be economically and practically feasible well before 2030.

The main findings are:

1. More than 800 coal power stations in emerging economies show potential to be profitably replaced by renewable energy.
2. Coal-to-clean transactions with a shift starting within the next five years are viable for the five specific opportunities assessed without subsidies, and capital can make an economic profit on investment. While philanthropy may need to partially subsidise the first deal or promise to take first losses to get the first deal over the line to convince the market that it is feasible, economics are lining up for private capital and utilities to proactively source and finance these deals. It is estimated that a positive economic return beats the weighted average cost of capital for the five projects identified.
3. Transactions can be structured to pay for all costs associated with a coal-to-clean transition. This includes not only the costs of coal facility shutdown and new generation capacity but also societal/public costs such as retraining directly and indirectly employed workers, upgrading grid infrastructure to support greater renewables, site decommissioning, recovery of the equity losses of shutting down an operational asset, and financing and power purchase agreement (PPA) restructuring costs.
4. While the design of a transaction depends on local context, some heuristics are evident:
    a. Scope: Some markets do not require energy storage because they are well integrated into regional grids; in others, storage is essential where coal is a substantial share of local power generation capacity. The scope of the solution should not be predetermined and can incorporate efforts to address indirect impacts and public goods in line with the principles of a just energy transition.

    b. Characteristics of a viable deal: Older coal plants (at least 10 years into operation), larger projects of more than 800 megawatts make for better opportunities (scale plus payoff for effort involved), a phasing of the ramp-up/down of the project to make implementation viable and a willingness to renegotiate an existing PPA and other contracts.

    c. Costs: Renewables costs in all the markets assessed were competitive with coal power (and other sources of generation). Because of this, it was found that energy prices can be kept constant in these markets and still make these deals work. In reality, energy prices have been rising regardless, while renewables offer something increasingly important in a world of sharply cyclic commodity prices, energy price stability.

   d. Timeline: The analysis shows that the closure of some coal power plants could be accelerated by 10 or more years, each yielding a substantial carbon reduction impact.

5. The PPA arrangement for renewables capacity allows one to raise enough debt and equity to finance all the costs of the transaction—including the decommissioning of the coal assets—and to cover the profit needs of both the dirty and clean energy players.

6. The right approach is an ambitious large-scale renewable energy buildout and replacement of coal power, tempered by phasing the rollout of the renewables over several years to allow the country to build up its supply chain, pool of skilled contractors and financing partners. This large-scale approach will lead to long-term cost efficiencies and the development of a local employment base that would be infeasible for smaller programmes.

7. Some challenges remain but are addressable in a systemic manner:

   a. Cost of capital has risen in a higher interest rate environment. This makes refinancing coal debt (raised when interest rates were very low or subsidised through guarantees, etc.) more expensive in some cases.

   b. Many markets have young coal plants with substantial time remaining on their independent power producer contracts. For example, in Vietnam, nine units totalling 5.6 gigawatts (GW) have been brought online since 2020 and another 27 units totalling 10.5GW were commissioned from 2015-2020.[1]

   c. The PPAs signed (IPPs for coal) in certain cases provide very attractive pricing or subsidies that make it difficult to buy the remaining value of the IPP contract.

   d. General inertia and regulatory capture also arise during discussions.

Introduction

Addressing climate change is a global imperative. While the precise mechanism to achieve this is being debated by nations and organisations at events such as COP, it is clear what the broad guiding principles need to be. According to the International Energy Agency, four key pillars can deliver a credible pathway to 1.5^{o}C and limit the impact of climate change: the decarbonisation of electricity, reducing deforestation, tackling non-carbon dioxide (CO_2) emissions, and carbon capture and storage (including atmospheric CO_2 removal).

In electricity, 75 countries worldwide used an installed base of 2,082 gigawatts (GW) of coal power in 2023.[2] This installed base emits approximately 15.5 gigatonnes of CO_2 annually,[3] which is around

[1] Extract from the Global Energy Monitor database.
[2] For this study, the Global Coal Plant Tracker (January 2023 version) from the Global Energy Monitor database was utilised, as well as other information available from the Global Energy Monitor, such as its plant facility wiki site. The database Includes facilities classified as announced, pre-permit, permitted, construction, shelved, cancelled, operating, mothballed and retired. For this study, only sites classified as 'operating' were included.
[3] 1 gigatonne is 1 billion tonnes. Source: International Energy Agency. Global CO2 emissions rose less than initially feared in 2022 as clean energy growth offset much of the impact of greater coal and oil use. 2 March 2023.

40% of the estimated 36.8 gigatonnes of CO_2 emissions emitted by global energy-related activities. This is a substantial and important market for which to find a solution.

But there are challenges to decarbonising electricity. Only 215GW (approximately 10%) of existing coal power capacity is slated for decommissioning by 2030 (see Appendix, 'Research'). Anecdotally, there are countries in which new coal power investments continue to be planned, with a high likelihood of proceeding. Few of the initiatives to decommission coal power realistically target dates as early as this decade. From interviews conducted, many of these transactions are considered possible only with significant quantities of philanthropic funding, concessional finance or government subsidies.

This paper aims to determine which coal assets can be decommissioned economically with an initial (small) philanthropic investment and no (or minimal) subsidies and prioritise those cases where impact can be achieved soon. The focus is on transactions that are broadly financially viable with limited or no subsidies and where the transition can start before 2030, with significant impact achievable by 2035.

This paper explores mechanisms that would work for decarbonisation, how to identify suitable projects, case studies of viable opportunities to decarbonise specific facilities by 2030 and next steps to realise these transactions. Others can leverage this approach to identify further opportunities.

I. Structuring the Coal-to-Clean Transaction

Approaches to Decarbonise Power Generation

There are many approaches to decarbonise power generation. This paper does not seek to explore all in detail but outlines a few and explains the transaction mechanism favoured here. Examples of approaches include:

- **Large-scale renewable asset build-out** coupled with the obligatory purchase of renewable power in preference of carbon-based power. In the long run, this leads to investment in excess market generation capacity, and market forces reduce the use of carbon-based generation capacity at times when renewables are in operation. Low utilisation drives up the costs of coal-based generation to the point where assets are forced to shut down. In many markets, issues around baseload capacity replacement, grid balancing and energy storage to support the transition are still being addressed. Renewables are established as a cost-competitive generation option in this approach. The U.S. and parts of western Europe have followed this model.
- **Commitments to shut down coal power plants** at full cost to the owner. This model is seen in markets where many of the coal facilities were built well before the 1980s, which could raise questions as to why they are still in operation. Given that the asset book value was written off decades ago and that many of these are state-owned assets, the costs, while

borne by the state, are mainly paper costs. Many eastern European countries fall into this category, as well as older assets in Asia and Latin America.

- **Specific coal power plants targeted for shutdown** by a combination of philanthropic and nongovernmental organisations, development banks and governmental agencies. While not many cases exist today, there are still several ongoing negotiated transactions happening in this group. Third parties, donor funding or other subsidies bear the loss in equity and outstanding debt payment costs. Examples include transactions underway in Indonesia and the Philippines.
- **Just energy transition partnerships (JETPs)**, initiatives led at the government level to identify and shut down coal power plants.
- **Coal power plants targeted for overhauls**, with investment to improve the efficiency of operations and reduce (but not eliminate) CO_2 emissions.
- **One (or more) of the above** that also incorporates clean credits to improve the transaction value.[4]

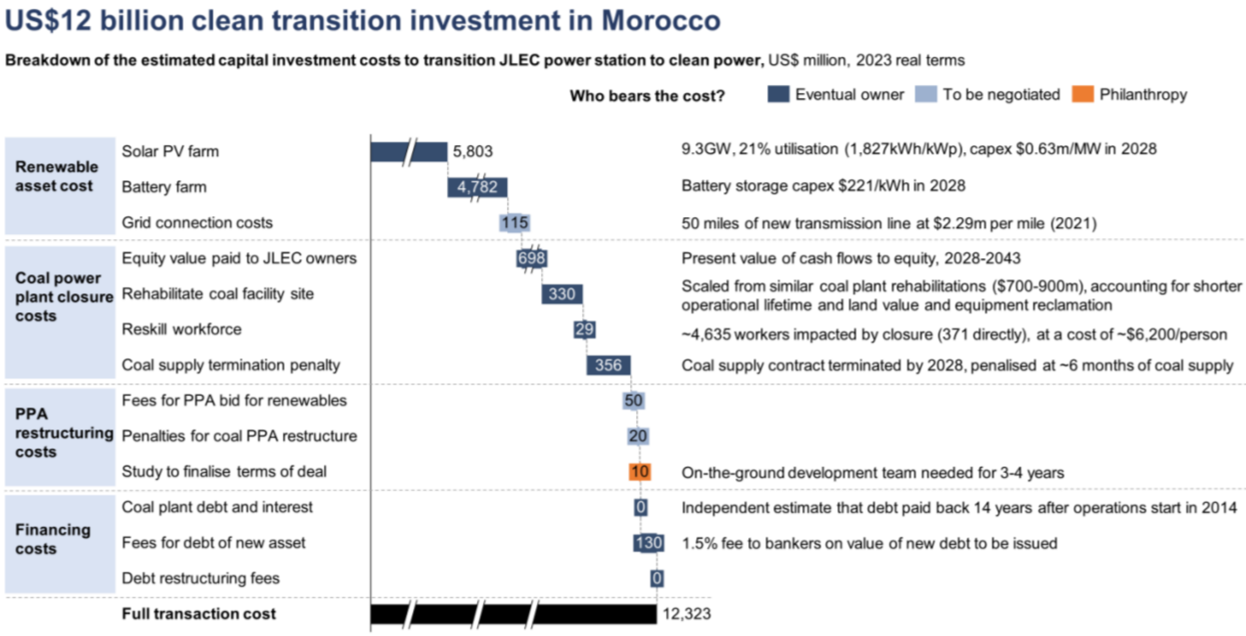
The impact of many of the above cases is limited because: It requires an owner that is willing to enter a transaction that may be negative or, at best, economically neutral; coal power plants' power purchase agreements (PPAs), coal purchase agreements and other contracts can be time-consuming and difficult to change; information about the economics of the facilities is opaque, making transactions challenging; only a few markets are focused on transactions, and many are ignored thus far; and the total cost of the coal-to-clean transition is not fully understood and becomes prohibitive without dedicated effort to assess it.

The Upfront Costs of a Transaction

Before looking at how transactions like this should be structured, this report explores the costs associated with a coal-to-clean transition—a key role in any transaction. The breakdown of the costs is based on primary research, the author's own experience and interviews with players in the market. A summary of this is presented in Figure 1.

[4] See the article, Methodology for Early Retirement of Coal-Fired Power Plants Using a Just Transition by the Rockefeller Foundation-led Coal to Clean Credit Initiative. 4 December 2023.

Figure 1: Overview of Likely Coal-to-Clean Costs for the Morocco Opportunity



Source: Global Energy Monitor, Lazard NCBI, WED, EPI, team analysis.
Note: to Date the Largest Single-Site Photovoltaic Facility in the World is ~3GW,[5] so this opportunity encompasses three of those sites.

There are four categories of cost in a coal-to-clean transaction, and each provides a comprehensive view of transaction costs and investment requirements. This research presents a perspective on the estimated scale of costs for each of these four categories, except for transmission grid network upgrade costs, where very limited public information was available (and which are less relevant for single-asset transitions). These four categories of upfront transaction costs are:[6]

1. **Cost of the new renewable generation asset**
   Within this category, there are four costs to consider: new generation capacity, energy storage system, grid connection (transmission lines) and grid upgrade. The latter was challenging to cost and was not included in the case studies assessed. This category is the largest by a significant margin, ranging from 63% to 88% of the total investment. The low end of the range applies to high solar irradiation cases or when storage is not included, while the high end of the range tends to apply to lower solar irradiation locations.

2. **Cost to close the coal power plant**
   There are five costs to consider in this category: the remaining equity value of the coal asset, other equity obligations associated with it (e.g., community ownership), coal site (and

[5] At time of writing, Golmud solar park, China. The Eco Experts. The 15 largest solar farms in the world 2024. 12 March 2024.

[6] The cost data for every country and facility evaluated was sourced from local reports or company financial statements. In cases where cost data was not publicly available, benchmarks or indicative costs were developed for each case and then adjusted to the specific transaction evaluated. Factors that influenced the range of costs included local currency to U.S. dollar exchange rate (uncertainty), local interest rates and cost of capital, localisation of photovoltaic (PV) and battery costs (in some markets, PV systems are far more expensive than the global average), and the age of the power plant (as a correlative proxy for efficiency, cost to operate, clean-up costs, remaining PPA contract term, etc., when these were not available).

potentially mine) rehabilitation, workforce reskilling and career transition (both directly employed and indirectly impacted), and coal supply termination. This cost range varies significantly, typically depending on the age of the coal plant, from 10% to 20% of the transaction cost. Higher transaction costs are tied to newer facilities where the equity value of the remaining contract term is still significant—for example, a coal independent power producer (IPP) built in the 2010s.

3. **Regulatory transaction and restructuring cost**
   Within this category, there are three costs to consider: fees for bidding for a new PPA for renewables generation (not always relevant), penalties to restructure the existing coal IPP PPA (not relevant for state-owned facilities, and the extent varies dramatically by local regulations), and costs of the study and development activities to progress the transaction itself. Overall, these costs are minor and come to 2% of the total at most (typically well below 1%).

4. **Financing costs**
   There are three costs to consider within this category: paying out the obligations of outstanding debt principal plus the interest that would be earned, costs to restructure the debt of the existing coal power plant and fees for raising debt for the new renewable generation capacity. These costs can vary dramatically, from 1% to 2% when very little debt remains outstanding to 15% to 20% for newer coal power plants with significant principal and interest outstanding.

The Coal-to-Clean Transition Model

In a coal-to-clean PPA transition, the developer or operator signs an agreement to sell power generated through renewable sources with the energy regulator or purchasing authority. The terms of the PPA link the construction of renewables capacity with the closure of a specific coal generation asset. The timing of the transaction sees the renewables built and phased in to coincide with a gradual ramp-down of the coal generation capacity with a commitment to permanently shut down the coal facility within a defined period. The terms of the transaction ensure that the developer's new asset development costs include the full transaction costs outlined in the prior section, resulting in financial compensation to associated parties (see sidebar, 'Terms of the transaction').

> **The terms of the PPA link the construction of renewables capacity with the closure of a specific coal generation asset.**

Terms of the Transaction

The terms of the transaction ensure financial compensation for the following parties:

- **The owner of the coal asset** receives a net present value-corrected payout for the equity share of the remainder of the PPA term for which the asset was contracted (if there is no PPA because it's a state-owned facility, the value of the equity can be tied to the anticipated remaining productive lifetime of the asset).
- **The owner of the renewable asset** (potentially the same entity as the coal asset) receives a 20- to 30-year PPA for the newly built asset.
- **Debtors** receive the outstanding principal and remaining interest without a haircut.
- **The government/public sector** receives income through PPA transaction fees, which can be invested into the transmission network. Alternatively, the developer or renewable operator can directly invest in grid upgrades as part of the transaction terms.
- **The employees** of the existing coal facility are compensated through training and job placement programmes, the cost of which is covered by the transaction costs outlined in the previous section.
- **Consumers** benefit because the economics of the transaction ensure that wholesale energy prices are unchanged (with long-term price stability or certainty because of reduced dependence on commodities).
- **The broader local community** sees new investment in renewable assets and a cleaner environment, while a provision has also been made to support the transition of the businesses tied to the coal business.

The transaction works primarily because the EBITDA generated by the renewables PPA is significant and guaranteed for 20 to 30 years. Coal power plant assets are targeted when their EBITDA margin is far lower than for a renewable facility.[7] By way of comparison, a typical EBITDA margin for renewable assets ranges from 75% to 90%, while for the coal power plants in the case studies, the EBITDA margins range from negative (that is, subsidised) to approximately 40%, with 20% being common for IPPs.[8]

Further, the cost of capital of renewable power facilities can be marginally cheaper than for fossil fuel-based assets, depending on the geography in question.[9] However, recently increased interest rates have undone these benefits for transactions where the coal power plants were financed under

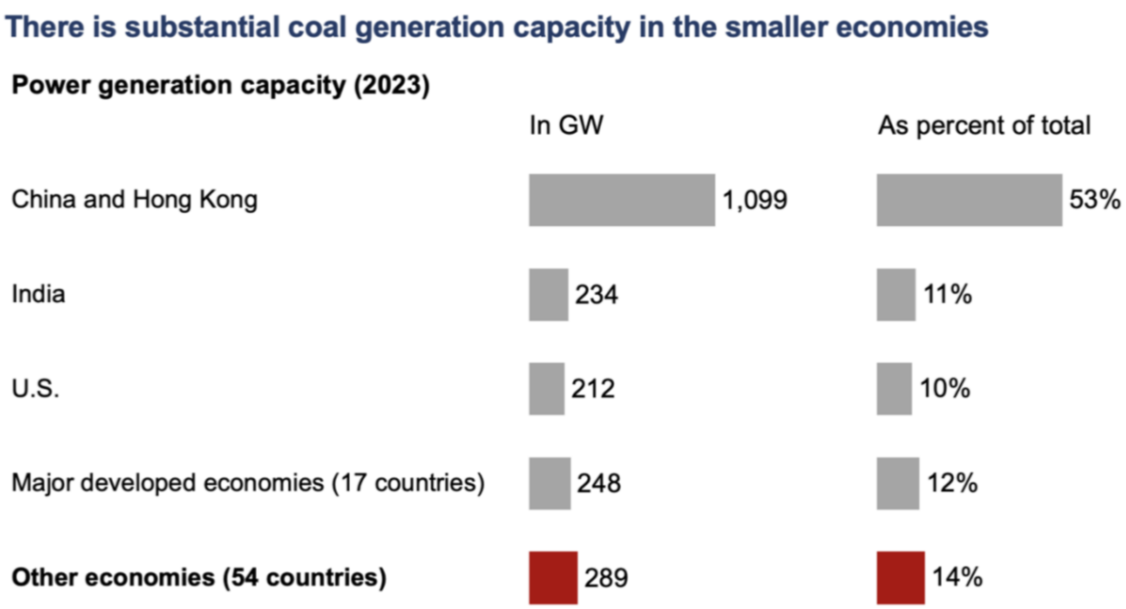
[7] This is an important point because, in some cases, coal power IPP facilities receive very attractive PPA terms, where wholesale prices and availability payments make them highly profitable. Anecdotally, this point has been confirmed through interviews.
[8] These are estimates by the authors based on published financial reports or our own approximations based on benchmarked data from sources including Lazard's Levelized Cost of Energy Analysis—Version 16.0 (April 2023), Botswana Power Corporation Annual Report 2021 (Botswana), IRPC Annual Report 2022 (Thailand), Electricity Generating Authority of Thailand Annual Report 2022 (Thailand), TAQA Annual Financial Report 2022 (Morocco), financial statements published by EBSA in 2020 (Colombia), Enel in 2022 (Colombia) and Gecelca in 2021 (Colombia), and press articles about Complexul Energetic Oltenia (Romania).
[9] Oxford Sustainable Finance Group. Energy Transition and the Changing Cost of Capital: 2023 Review. March 2023.

cheap or partially subsidised debt interest rate regimes. The cost of capital helps but was not found to be an essential contributor to the economics.

II. Finding the Right Projects for a 2030 Transition

A standard transaction model was used to analyse coal-to-clean PPA transactions (data and specific assumptions were tweaked to local market conditions; see Appendix, 'Research'). The analysis focused on the group of emerging market countries and territories highlighted in Figure 2.[10] This long tail of countries together accounts for around 290GW of installed coal power generation capacity.

Figure 2: Distribution of Coal Generation Capacity in 2023



Source: Global Energy Monitor database, analyst calculations.

[10] These emerging markets include Argentina, Bangladesh, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Bulgaria, Cambodia, Chile, Colombia, Croatia, Czechia, Dominican Republic, Greece, Guadeloupe, Guatemala, Honduras, Hungary, Indonesia, Kazakhstan, Kosovo, Kyrgyzstan, Laos, Madagascar, Malaysia, Mauritius, Mexico, Mongolia, Montenegro, Morocco, Myanmar, Namibia, Nigeria, North Korea, North Macedonia, Pakistan, Panama, Philippines, Poland, Romania, Senegal, Serbia, Slovakia, Slovenia, South Africa, Sri Lanka, Tajikistan, Thailand, Türkiye, Ukraine, Uzbekistan, Vietnam, Zambia and Zimbabwe.

The opportunity for transitioning coal to clean in the economies highlighted in Figure 2 is substantial. The 54 ‘other economies’ show the combined characteristics of converting the 289GW of coal generation capacity (see below, ‘Other economies' characteristics’).

Other Economies’ Characteristics

The 54 other economies analysed had the following characteristics:

- Emissions from this coal generation capacity are estimated as 1.7 billion million tonnes of CO_2 per annum.[1]
- Transition to renewables plus storage could require 940GW to 1,250GW of solar power installation.[2]
- The capital investment of the solar capacity could cost approximately US$600 billion to US$810 billion[3] (in forecasted 2026 prices), with approximately another US$680 billion required if eight-hour battery storage is included.
- The assets within this group are varied as well. Of the 1,329 units included:
    - 629 units representing around 120GW are older than 30 years.
    - 192 facilities representing 44GW are 15 to 30 years old, the ideal sweet spot for targeting for coal-to-clean projects as transactions are likely to be viable before 2030.
    - 508 facilities representing 125GW are younger than 15 years and are likely to be attractive for coal-to-clean transactions towards the mid-2030s.

[1] Assumes an average facility utilisation of 65% and 1.92 metric tons of CO2 emitted per kilowatt-hour.
[2] This assumes the coal is fully replaced by solar power photovoltaics, which is purely illustrative as other generation technologies are also relevant. This range assumes solar utilisation of 15%-20%, which is a typical range for the relevant regions.
[3] This assumes an average solar potential of 1,300 hours per megawatt (15%) to 1,750 hours per megawatt (20%) with eight hours of battery storage at an average cost of US$650 per kilowatt peak (2026 forecast) for solar power and US$225 per kilowatt-hour for battery storage (2026 forecast), as used for the opportunities assessed in section 3 of this report.

One of the findings of this work is that not all coal generation assets present a viable economic case for decommissioning and replacement before 2030. The characteristics of suitable assets identified were approximately the following:

- Built before 2015, preferably between 1990 and 2010
- At least 1GW capacity preferable
- Countries without onerous PPA legislation and subsidies to power plants
- Clarity about debt holders
- Existing IPP framework
- Coal IPP owners demonstrating an interest in disposing of their coal assets
- Able to be linked or bundled
- Countries where power demand will grow
- Countries that import coal and/or gas

In addition, a project is considered viable when:

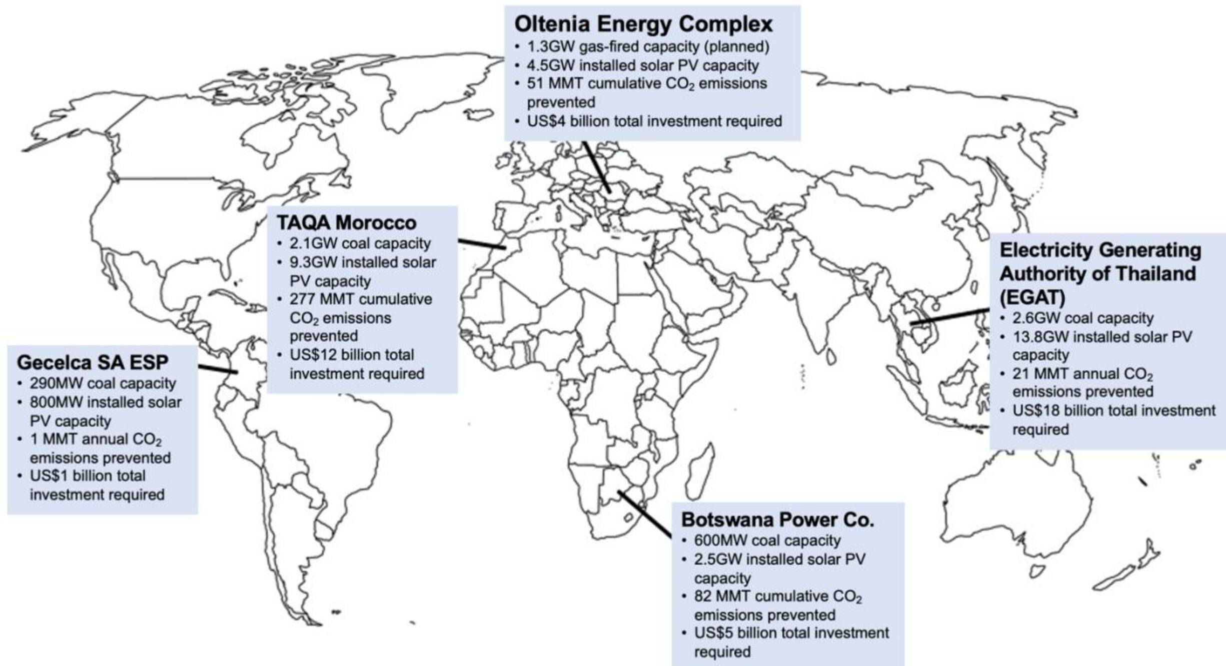
- The wholesale price of electricity in that country does not increase outside of the estimated 2023 price for the existing energy generation mix, accounting for local inflation rates
- The owner(s) and debtors of the coal asset are made financially whole (that is, all the debt is paid off with outstanding interest and the remaining intrinsic equity value of the asset is paid out)
- The cost of grid upgrades to enable the inclusion of renewables is included
- The local population is supported financially with job retraining
- The costs of decommissioning and site rehabilitation are included
- The new assets meet their weighted average cost of capital (WACC) and debt repayment requirements
- Capital subsidies are not needed

III. Five Case Studies for Potential Immediate Action

From this large pool, seven cases in five countries were further explored: Botswana, Colombia (two cases), Morocco (two cases), Romania and Thailand. Five specific opportunities were identified among these five countries that together represent approximately 8GW worth of coal assets, where it is economically profitable to run a PPA programme to replace coal generation with an investment in renewables generation (and, in some cases, with energy storage). These five cases have a profit margin from the renewable asset that is more than enough to pay for the full upfront transaction and coal plant closure costs while still generating an economic profit for the operator of the power facility.

The economics indicate that if the renewables are operational in the 2026 to 2028 timeframe, these five projects could completely end CO_2 emissions by the end of 2028. All five of these projects were found to be viable without major subsidies except for some upfront funding for the development of a bankable investment case. These upfront subsidies would provide the ideal entry point for philanthropy to play a role in the transactions (discussed later). The details of these cases are presented in Figure 3 (see Appendix, 'Summary of opportunities', for the full details).

Figure 3: Map of Five Viable Projects



Source: IEEFA, from company reports, analyst calculations.

IV. Cases that Present a Challenge to Viability: How to Act

Unlike those exhibited in Figure 3, two cases were also identified where viability was a challenge. One of these is outlined below in Table 1. For these assets where the economics do not work, a mixture of subsidies, debt write-downs, a delay in closing the coal plant to the early 2030s and reduced (or no) storage capacity, together with carbon credits, can shift the economics to make the transactions economically viable. Four alternatives can make the transaction viable, provided other circumstances do not change (see sidebar, 'Alternatives to make the project viable').

For these cases to become viable transactions before 2030, they require reductions in the investment cost, discounts in cost of capital, public or philanthropic grants, or increases in wholesale power prices. The project in Table 1 becomes viable toward 2038 to 2040, particularly as debt levels are paid down and the asset and its PPA agreements age.

Table 1: Case Where Economics Do Not Work Before 2030

Power Plant Background	
Entity name	Safi Energy Company
Government owned?	No
Power station name	Safi
Location	Cap Ghir Safi
Country	Morocco
Coal capacity	1.4GW
Year operational	2018
Details of PPA to Replace Coal With Renewables	
Replacement tech applied	Solar plus eight-hour battery storage
Installed solar PV capacity	6.0GW
Currently planned retirement year	Unknown, existing PPA ends in 2048
Targeted retirement year	2028 (20 years early)
Investment Details	
Total capex	US$9.8 billion
New asset	US$7.1 billion
Coal buyout	US$2.7 billion
WACC (blended equity and debt)	5.3%
Wholesale energy price	US$0.057 per kilowatt-hour (kWh)
% increase from existing wholesale price	0%
Estimated NPV on investment[15]	Negative

Alternatives to Make the Project Viable

Table 2: Four Alternatives to Make the Project Viable

1. Raise Wholesale Power Price	
New wholesale energy price	US$0.076/kWh
% increase from existing wholesale price	+33%
Estimated net present value (NPV) on investment	US$1.8 billion
Finding	Infeasible as power becomes unaffordable
2. Reduce Upfront Investment Cost	
Investment cost reduction required	US$2.1 billion
Estimated NPV on investment	US$1.3 billion
Finding	Difficult to practically achieve
3. Reduce the Cost of Capital Through Concessionary Financing	
Target WACC	3.1%
Estimated NPV	US$1.2 billion
Requirements	Cost of debt to decrease from 6.8% to 4% and cost of equity from 12.1% to 7%
Finding	Difficult to achieve as it requires ~40% of financing (US$4 billion) to be supplied by concessionary finance
4. Shift the Planned Transaction to a Later Year	
Target year of closure	2038 (10 years early)
Estimated NPV	US$0.9 billion
Finding	Feasible, provided debt on coal power plant is paid down substantially by 2038

In the case of the Safi power plant, the options to achieve the US$2.1 billion reduction in investment cost are challenging:

- Removing 65% of battery storage saves US$2.1 billion but eliminates the opportunity to turn solar power into reliable baseload capacity for the grid in a country that is forecasted to have no reserve margin by the 2030s.[11]
- Negotiating the write-off of US$0.9 billion in outstanding debt and interest (or conversion to equity), cancellation of coal supply termination costs, site rehabilitation costs and all other fees, and the write-off of equity payments to the owning consortium remains insufficient. Another US$1.2 billion in subsidies or a partial reduction of battery storage capacity is needed for the difference.

[11] National Renewable Energy Laboratory. Load Forecasting for the Moroccan Electricity Sector. August 2021.

V. Achieving the Coal-to-Clean Transaction Opportunity

These five opportunities demonstrate that decarbonisation presents a compelling value proposition, as it can be an opportunity to invest in a coal-to-clean transaction, rather than a pure decommissioning of coal. Now, governments, investors and philanthropic organisations need to build on these opportunities. This can be achieved in two ways:

1. Dedicating time to identifying more specific transaction opportunities that can work in the next three to five years.
2. Investing in funds to establish local teams in the countries identified that will create a bankable business case by running due diligence.

In the countries examined, there are currently limited resources to develop these ideas into viable transactions. A dedicated team—the 'coal transition facilitator'—is needed to develop a complex programme like this, requiring contributions from a few different stakeholders in the transaction. These stakeholders include the incumbent utilities, coal asset owner, clean asset developer, investors and bankers, local regulators and government. Eventually, this team would see whether the transaction is feasible and hand it over to the eventual clean asset developer. If the transaction is not feasible, the team should aim to confirm this as quickly as possible so that resources can be directed elsewhere.

This facilitation of the transaction would include activities such as deep financial and economic analysis and diligence of the specific transaction. The team would bring expertise in complex debt restructuring and experience working with state-owned entities, regulators and local policy advocates. It would also take on identifying and bringing in suitable renewable energy developer(s) and clean asset investor(s). In addition, the team would lead outreach to the existing asset's owner, equity investors and debtors to establish a shared understanding of the options for decommissioning and develop an overall informed perspective on the local market and how a complex transaction like this could be done.

While there are organisations involved in coal-to-clean transactions today, they do not quite play the role just described. Typically, they play a range of roles, from preparing country and market insights to laying the policy groundwork for the JETP programmes (including organisations such as the Asian Development Bank, Carbon Trust, the Coal Asset Transition Accelerator, the Glasgow Financial Alliance for Net Zero, Transition Zero and others). The proposed local teams would require some global support in ensuring they apply best practice in project development and financing practices, and to learn from other markets.

Philanthropy can play a catalytic role by funding these transition facilitation teams. Funding should also come from private financial institutions and multilateral and regional development banks. This programme is an excellent opportunity for financial institutions to fund decarbonisation efforts and create their own deal flow of bankable coal-to-clean transactions.

Starting with a small transaction is not necessarily the right approach. Rather, an ambitious large-scale renewable energy buildout programme, coupled with the replacement of coal power, is more likely to be viable (think in terms of billions of U.S. dollars in renewables capacity). The are several reasons for this:

- Large-scale programmes can attract tens of billions of capital investment into a country. For the economies this report looked at, this is both transformative for the country's energy landscape and its economic potential.
- Political and regulatory policies required for a coal-to-clean transition programme can present a significant investment of time and complexity; the effort remains the same, regardless of scale, but an ambitious programme will create a better incentives upside and pay better rewards for all the effort involved. A small-scale programme will inevitably be underwhelming.
- A large-scale approach will lead to long-term cost efficiencies and the development of a local employment base, which would be infeasible in the case of smaller programmes.
- Compared to the generation investment required, the capital cost to upgrade the transmission grid to accommodate renewables pales and could be incorporated into the overall transaction costs. Such investment programmes are more likely to become national priorities and draw in resources than small, piecemeal initiatives.

The challenges of a large-scale programme can be tempered by phasing the rollout of the renewables over several years to allow the country to build up its supply chain and pool of skilled contractors and ready financing. Because renewables are utilised, this scaled approach is more feasible than the typical single large-scale investment decisions needed in sectors such as coal or nuclear power. Further work could focus on the other countries shortlisted earlier in this report, including, for instance, Brazil, Chile, Czechia, Greece, Guatemala, Kosovo, Mexico, the Philippines, Vietnam or Zambia.

It is hoped the discussion around this topic continues and all parties seriously develop opportunities for a coal-to-clean transaction in the next three to five years. Global economies and the climate will depend on it.

Appendix

Research

1. Approach to Identifying Coal Power Plants

Information about the number of coal power plants in each country, the capacity of those plants and the status of those assets classified as announced, pre-permit, permitted, construction, shelved, cancelled, operating, mothballed, retired or a planned retirement date was sourced from the Global Coal Plant Tracker (January 2023 version) provided by the Global Energy Monitor database and Global Energy Monitor's wiki site for each facility. For this study, only sites classified as 'operating' were included. No issues were found with the information in the database, although information on the wiki was double-checked when possible.

General analyses about the amount of coal power, by country, were all estimated from this database. In addition, this database was used to filter and identify the power plants that were eventually used for deep dives.

Using this database and heeding counsel from others, the full list of 54 countries and territories mentioned in Figure 2 was filtered down to 14 countries. A high-level market assessment of these 14 countries then led to the selection of five countries where each coal power plant was assessed before seven case studies were developed in these five countries.

2. Approach to Modelling the Transactions

Different approaches to the transactions were identified and researched before landing on the approach used in this paper. The model applied here assumes that the transaction links the closure of existing coal power plants to issuing a new PPA for providing replacement power via renewables. The model also assumes that baseload generation capacity can be approximated using renewables by co-investing in energy storage. Solar power and battery storage technologies were used in all the calculations because the economics are well known, which allows for more transparency in the analysis. The costs of these technologies were forecasted forwards based on data showing their long-term historical cost trajectory. Other power and storage technologies could also be viable, and the final answer will depend on the specific conditions of each project.

It was decided that the transaction financial models would include all costs associated with a coal-to-clean transition, even those traditionally assumed as a government's responsibility (such as the social costs of reskilling and transitioning coal employees to other industries). The intent was to see how much of a transaction could be funded via traditional commercial project finance principles before resorting to other, lower-cost sources of financing such as concessions, subsidies or debt forgiveness.

The modelling of the transactions included the following:

- An algorithm to estimate the capacity of renewables and storage necessary to replace the annual gigawatt-hour provided by the existing coal power plant (assuming a utilisation for that coal power plant)
- An algorithm to estimate the capital costs of constructing that new generation and storage capacity, which includes an estimation of the project costs discussed in Figure 1
- An algorithm to estimate operating costs for coal and solar power, using global data adjusted based on available information for the particular country or facility being evaluated, adjusted to a local currency basis including local inflation effects (extrapolated as the long-run average of earlier decades)
- An estimate of wholesale power prices in that market, in local prices including escalation based off long-run anticipated inflation (extrapolated as the long-run average of earlier decades)
- A local currency to U.S. dollar conversion algorithm using historical data and extrapolated forwards based on the ratio between the long-run forecasts of the U.S. inflation rate versus the local country inflation rate
- A pre-tax cash flow model for the existing coal power facility and the new solar power facility (using EBITDA less capex as a proxy for free cash flows), from which NPVs were calculated
- The NPV for the coal power plant was calculated as the NPV of the shortened lifetime of the asset (if coal to clean occurs) less the NPV of the anticipated remaining lifetime if no transaction occurs—this was typically a negative number (if the facility was profitable)
- The NPV of the transaction was calculated by taking the NPV of the solar power transaction and then subtracting from that the NPV of closing the coal power plant to test that all costs of closing the coal power plant could be covered by the transaction and still deliver a positive overall NPV
- A model to estimate the outstanding coal and solar power plant debt, using the assumption that ~80%-90% of EBITDA cash flows are directed to pay off principal and interest. Interest was calculated using a declining balance approach, and the principal repayment was calculated as the residual after the annual interest obligation was accounted for
- Debt levels for each project were set using the above approach, ensuring that debt service coverage ratio (DSCR) always exceeded 1.2 while full debt principal repayment occurred before the PPA lifetime of the solar power plant ended

3. Calculating the Cost of Capital

WACC is a common project finance concept. This report follows the traditional approach of calculating WACC as the weighted average of the cost of debt and cost of equity, accounting for the tax shield. The cost of equity was calculated using the capital asset pricing model (CAPM) for estimating the risk-adjusted rate of return (see Table A). This provided the basis for cost of equity for traditional fossil fuel-based power projects. For renewables, this cost of equity was discounted by 100 basis points (bps). Research by the Oxford Sustainable Finance Group found that in some markets, the cost of capital of renewables was lower than for fossil fuel projects.[12] This was verified by interviews and applied as a general principle for the equity calculation.

The cost of debt was adjusted by adding basis points to the risk-free rate of return of typically 200 bps for renewable projects. However, for fossil fuel projects, a wider range of interest rates was used, typically calculated from the annual report for that business. It was often found that the debt rate was relatively cheap for the fossil fuel plants versus what one could expect for commercial debt in a power project in 2023. Reasons for this may vary. The share of debt in the transaction was calculated to be the maximum theoretically allowable while keeping the DSCR of the transaction above 1.2. It might be argued that relatively high levels of debt have been used in this analysis, but in each case the DSCR remained greater than 1.2, which is a typical basis used to calculate share of debt.

Overall, it was found that project economics were not that sensitive to WACC assumptions.

Table A 1: Assumptions for Calculation of WACC at Time of Analysis (2023)

Country Name	Corporate Tax Rate	Risk-Free Rate of Return	Total Equity Risk Premium	Risk-adjusted Rate of Return for Equity
Botswana	22%	7.5%	6.8%	14.3%
Colombia	35%	9.9%	7.9%	17.8%
Morocco	35%	4.3%	8.8%	13.1%
Romania	16%	6.5%	8.3%	14.8%
Thailand	20%	2.5%	7.4%	9.9%
U.S.	-	3.8%	-	-
Rationale	*Web search for publicly available information*	*10-year national treasury bond rate*	*pages.stern.nyu.edu*	*Calculated using CAPM model, with Beta = 1.*

[12] Oxford Sustainable Finance Group. Energy Transition and the Changing Cost of Capital: 2023 Review. March 2023.

Table A 2: Assumptions for Calculation of WACC for Existing Coal Power Plant in Morocco at Time of Analysis (2023)

Country Name	Cost of Debt	Cost of Equity	Share of Debt	WACC
Morocco	4.8%	13.1%	80%	5.1%
Rationale	*TAQA 2022 annual report reported interest payments approximating 4.8% (50 bps higher than risk-free rate)*	*Calculated risk-adjusted rate of return for equity*	*Calculated based on DSCR of 1.2*	*Calculated*

Table A 3: Assumptions for Calculation of WACC for New Renewable Power Plant in Morocco at Time of Analysis (2023)

Country Name	Cost of Debt	Cost of Equity	Share of Debt	WACC
Morocco	6.8%	12.1%	88%	5.3%
Rationale	*Assumed as risk-free rate plus 250 bps*	*Assumed that green energy gets 100 bps discount vs. fossil fuel*	*Calculated based on DSCR of 1.2*	*Calculated*

Table A 4: Summary of Opportunities

Power Plant Background					
Entity Name	TAQA Morocco	Botswana Power Co.	Gecelca SA ESP	Oltenia Energy Complex	Electricity Generating Authority of Thailand (EGAT)
Government owned?	No	Yes	Yes (but privately operated)	Yes	Yes
Power station name	Jorf Lasfar	Morupule B	Termoguajira	Portfolio of four assets[13]	Mae Moh
Location	El Jorf Lasfar, El Jadida Province, Doukkala-Abda	Palapye	Dibulla, Guajira	Gorj and Dolj	Mae Moh district, Lampang
Country	Morocco	Botswana	Colombia	Romania	Thailand
Coal capacity	2.1GW	600MW	290MW (50% utilisation)	Government plan is to replace with 1.3GW gas plant	2.6GW, with plans to reduce to 1.2GW after 2030
Details of PPA to Replace Coal With Renewables					
Replacement tech applied	Solar plus 8-hr battery storage	Solar plus 8-hr battery storage	Solar (no storage)	Solar plus 4-hr battery storage	Solar plus 8-hr battery storage
Installed solar PV capacity	9.3GW	2.5GW	800MW	4.5GW	13.8GW
Investment Details					
Total capex	US$12.4 billion	US$5.1 billion	US$1.0 billion	US$3.8 billion	US$17.7 billion
• New asset	US$10.8 billion	US$3.2 billion	US$0.8 billion	US$3.8 billion	US$15.5 billion
• Coal buyout	US$1.6 billion	US$1.9 billion	US$0.2 billion	Not applicable	US$2.2 billion
WACC (blended equity & debt)	5.3%	8.3%	8.1%	8.1%	3.4%
Wholesale energy price	US$0.059/kWh	US$0.120/kWh	US$0.093/kWh	US$0.101/kWh	US$0.057/kWh
% increase from existing wholesale price[14]	+1%	0%	+4%	0%	+4%
Estimated NPV on investment[15]	Up to US$2 billion	Up to US$740 million	Up to US$200 million	Up to US$0.4 billion	Up to US$1.4 billion
Impact Estimate					
Currently planned retirement year	2044 (PPA ends)	2043 (30-year asset life)	Unclear	Between 2025-2030; natural gas plant would run until 2045	1.4GW to close by 2026; remainder unclear
Year retirement completed by	2028 (16 years early)	2026	2026	2026	2026
Cumulative CO_2 emissions prevented	277 million metric tons (MMT) of CO_2	82 MMT CO_2	1 MMT CO_2 (annual basis)	51 MMT CO_2 (natural gas plant emissions)	21 MMT CO_2 (annual basis)

[13] This complex comprises four power plants, Craiova II, Isalnita, Rovinari and Turceni.
[14] The wholesale energy price paid to the generating utility relative to the existing market wholesale price in year one.
[15] Assumes a 20-year PPA. NPV accounts for all costs to transition from coal power facility to renewables plus storage, including paying down the remaining value of the coal asset (debt and equity).

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