REPORT

CAUTION ON CO-FIRING, RETROFITTING, AND CARBON CREDITS FOR RETIREMENT

Considerations for public development banks on coal phase-out risks

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/Λ 01 INTRODUCTION

To reach climate objectives and avoid the worst impacts of climate change, it is essential to both halt the construction of any new coal-fired power plants and retire a significant share of the global fleet before the end of their technical lifetime. Associated with this discussion are the questions of how to bring about a just transition and shift utilities from fossil fuels towards renewables, but also of what to do with the existing infrastructure and sites.

With their historical role in funding coal capacity and public mandate, public development banks have a crucial role in enabling coal phase-out. A growing number of public development banks and countries have pledged through the Clean Energy Transition Partnership and institution-specific policies to stop financing new coal power generation in line with the Glasgow Climate Pact's call to phase down "unabated coal power" (COP26 Presidency, 2021). This pledge was renewed more recently, during COP28, as the global stocktake decision text called to accelerate efforts "towards the phase-down of unabated coal power" (UNFCCC, 2023). However, the caveat "unabated" opens the door for abatement technologies which threaten to undermine rapid phase-out efforts. Various national phase-out strategies include propositions that promote co-firing with other fuels such as biomass, hydrogen or ammonia (Giseburt, 2022; CAT, 2023a, 2023b). Others promote retrofitting existing infrastructure with carbon capture and storage technology (IEA, 2020). As there is no consensus on a definition for transition finance nor technical criteria for qualifying sectors (Tandon, 2021), there is a high risk of using scarce public funds to enable technologies that result in little decarbonisation impact.

Phase-out will require significant funds to incentivise early retirement and capital investment to build up renewable alternatives coupled with energy storage. Public development banks can play an integral role in enabling private investment in phase-out but should proceed cautiously to ensure they do not inadvertently set perverse incentives.

This report explores many of the risks associated with proposals for abatement technologies and carbon credits in more detail as an input to current discussions on early coal retirement. This analysis is based on a review of coal phase-out and transition literature, a series of workshops and interviews with experts, and current policy developments. In exploring the risks, we encourage caution when public development banks consider these proposals to avoid the inefficient use of public funds and inadvertently prolonging coal dependence. The report starts by addressing co-firing, then discusses carbon capture and storage, and concludes with examining carbon credits before presenting final thoughts.

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CO-FIRING AND COMPLETE CONVERSION

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Several coal-dependent, high-emitting economies promote co-incineration (co-firing) or complete conversion of coal plants to alternative fuels as a decarbonisation solution. However, co-firing and complete conversion present material risks to reaching energy targets and threaten to lock in further dependence on coal. Retrofitting to co-fire could create perverse incentives to keep plants online longer to recover not only the initial investment but also the costs associated with retrofitting. If a coal plant is not operating at a high-capacity factor, retrofitting investments become increasingly inviable. Co-firing or the potential to switch to alternative fuel in the future should not be utilised as justification to extend the life of fossil infrastructure today. To avoid extending the lifetime of coal plants and locking in high-emission technologies, public development banks should avoid investments to retrofit existing plants or build new coal plants with co-firing capacity. The following subsections introduce different types of co-firing and complete conversion and their associated risks.

2.1 CO-FIRING WITH BIOMASS

International greenhouse gas emission inventory guidelines treat biomass as carbon-neutral at the point of combustion because it is assumed that its emissions are balanced out by the carbon absorbed during the growth of the biomass (UNFCCC, 2009). To avoid double counting emissions, biomass combustions are reported under forestry and other land use (AFOLU) which can lead to the perception that biomass is carbon neutral.

Direct co-firing with biomass involves partially substituting coal with biomass from organic matter or waste material. The biomass industry and other proponents claim that co-firing with biomass can reduce coal use and carbon dioxide (CO_2) emissions (Drax Group, 2023). This has historically been supported by international greenhouse gas (GHG) emission inventory guidelines that treat biomass as carbon-neutral at the point of combustion (UNFCCC, 2009). Recent research, however, finds that biomass combustion emits high levels of CO_2 alongside other hazardous air pollutants (Song and Lim, 2022). More accurate emission accounting has found that the lower energy density of biomass can increase overall emissions (Schlesinger, 2018) and that the lifecycle emissions with biomass-fired power plants are often higher than solely coal-fired power plants (Stashwick et al., 2021).

Lifecycle emissions vary depending on the sourcing of the feedstock.

While co-firing with a ratio of 20% biomass is possible, co-firing at a percentage over 10% raises risks of technical problems (Sugiyono et al., 2022). Today, most plants with direct co-firing utilise less than 10% biomass, raising questions about the cost-effectiveness of co-firing retrofits if those retrofits only enable a low share of biomass alongside continued coal combustion.

Despite concerns about the **limited emission reduction potential and cost-effectiveness** of biomass co-firing, many countries plan to use it to reach energy sector decarbonisation targets. In Indonesia, state-owned utility PT Perusahaan Listrik Negara (PLN) aims to co-fire biomass in at least 52 coal plants by 2025 to support the government's renewable energy target (PLN, 2023). The plan would require 4-8 million tonnes of biomass annually (Bisnis Indonesia, 2021). Indonesia's JETP Comprehensive Investment and Policy Plan anticipates that biomass co-firing will constitute over 9% of the output from coal-fired power plants beyond 2040, in addition to a major role for bioenergy electricity generated in standalone plants (JETP Secretariat, 2023). In Japan, the government highlights accelerating biomass co-firing to achieve power generation efficiency targets, although it does not guarantee emission reductions (Japan Beyond Coal, 2021). As of 2020, about half of the country's coal plants are co-fired with biomass (Giseburt, 2022).

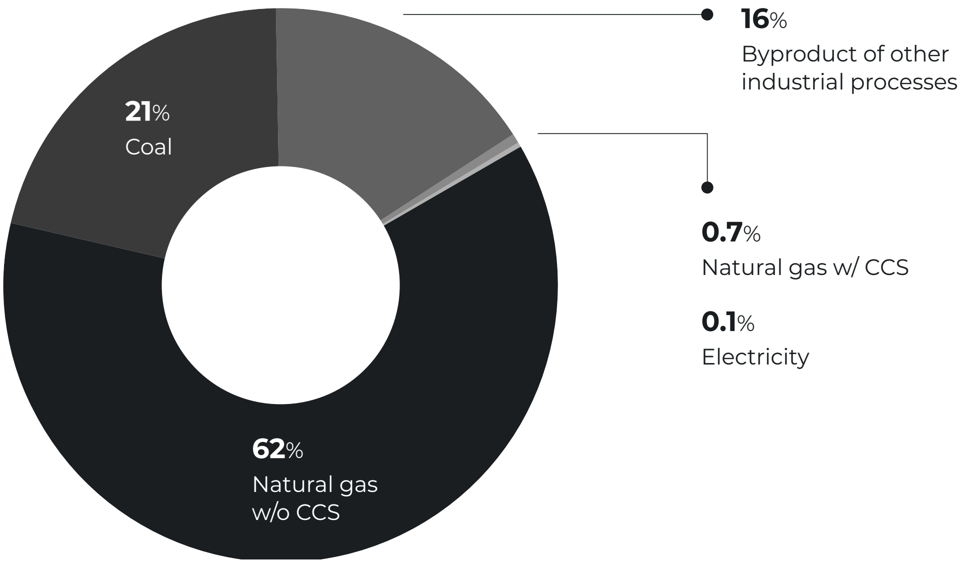
2.2 CO-FIRING WITH AMMONIA / HYDROGEN

Co-firing with power-to-X (PtX) fuels, like green ammonia or green hydrogen, similarly represents a false solution to meet necessary decarbonisation targets. Co-firing with PtX fuels is an extremely energy-intensive process with significant efficiency losses. If renewable energy is used to produce green hydrogen, converted to ammonia, and co-fired, about 75% of energy is lost during production, conversion, and transportation (Fekete et al., 2023). Efficiency losses along the production chain mean that electricity from co-firing will likely remain more expensive and less efficient than electricity generated directly from renewables, assuming the government is not subsidising the process (BloombergNEF, 2022). With high-efficiency losses inherent in producing green hydrogen and ammonia, investments in co-firing are increasingly at risk of stranding as coal becomes less economically competitive.

Today, almost all hydrogen is produced from unabated fossil fuels. Unabated natural gas is the feedstock for 62% of global hydrogen production, and unabated coal is used for a further 21%, mainly in China. Hydrogen from electrolysis represents less than 0.1% of hydrogen production (IEA, 2023b) **(→ Fig. 1)**. The vast majority, 85%, of global ammonia is produced with the Haber Bosch process (Aziz et al., 2020), where fossil gas (methane) reacts with steam and air at high temperatures.

Fig. 1

Global hydrogen production by technology



Source: IEA 2023b.

Co-firing with hydrogen or ammonia offers **limited emission reduction potential** and could even increase emissions. The emission reduction potential of co-firing depends on the energy source and production method employed to generate the PtX fuels. In fact, Heinemann and Kasten (2019) found that hydrogen produced with electricity only has a climate benefit when produced with over 70% renewable energy. Estimated annual fossil fuel emissions with different coal and ammonia co-firing mixes indicate emissions can increase if ammonia is produced with fossil fuels and that co-firing with green ammonia results in minimal emissions reduction (Erlandsson and Rimaud, 2022). A limited supply of low-carbon fuels today means that most co-firing in the near term will be with carbon-intensive fuels and result in minimal emissions reduction.

Co-firing for power generation diverts a limited supply of synthetic green fuels from decarbonising hard-to-abate sectors. Green hydrogen and green ammonia can be used in a number of end uses but should be reserved for applications where they can have the most significant emission reduction impact – i.e., hard-to-abate sectors where direct electrification is not viable (Liebreich Associates, 2021). Direct electrification with renewables is often more energy- and cost-efficient and should be a first-order consideration for power generation.

2.3 COMPLETE CONVERSION

As existing coal power plant infrastructure becomes increasingly stranded, some argue that plant conversions – from coal to fossil gas, biomass, or synthetic fuels – can smooth the transition by allowing for the continued use of existing infrastructure. However, plant conversion represents a false solution **with incomplete emissions reduction** that does not eliminate the significant risk of stranding or the necessity for early retirement (Lu et al., 2022).

While fossil gas is often referred to as a transition fuel, its expansion and the promotion of converting coal plants to fossil gas plants compromises keeping within the 1.5°C temperature target (Climate Action Tracker, 2022). Methane leakage from fossil fuel production and transportation and storage infrastructure may offset the CO_2 emissions reduction potential of substitution (Wigley, 2011; Gordon et al., 2023).

PtX-ready refers to plants that are designed and prepared for conversion to hydrogen or ammonia in the future. However, in the near term or until there are sufficient and cost-competitive green synthetic fuels available, they will run on fossil fuels.

As noted, when firing synthetic fuels, emission reduction potential heavily relies on the production method. Synthetic fuels produced with fossil fuels could result in limited or no emission reduction (Heinemann and Kasten, 2019). Retrofitting plans rely on the future availability of cost-competitive green fuels, a challenge that demands substantial production scaling and poses notable uncertainties. High costs of investments today into new or retrofitted "PtX-ready" infrastructure risk locking in emission-intensive development pathways and exert pressure to recoup investments, extending the lifetime of potentially uncompetitive assets.

As noted with co-firing, biomass conversions face limited emission reduction potential and could lead to increased air pollution and damaging public health consequences. As discussed below, biomass sourced from organic matter could have adverse impacts on the environment and agriculture. Biomass sourced from waste material also produces hazardous air pollutants and could lock cities into high-carbon pathways by encouraging sustained high-waste production (C40, 2019).

2.4 RISKS ASSOCIATED WITH CO-FIRING AND COMPLETE CONVERSION

In addition to the limited emission reduction potential and efficiency concerns of using biomass and PtX fuels to displace coal by co-firing and complete conversion, this report highlights three other key risks: lock-in risks, air quality concerns, and impacts on agriculture, forestry, and food security.

Lock-in risks

Betting on co-firing or "conversion-ready" power plants risks locking in dependence on coal into the future and delaying the deployment of renewable energy alternatives. Today, co-firing with green ammonia is technically feasible at a 20% blend rate, meaning 80% of the fuel is coal (Kennedy et al., 2023). Biomass is similarly co-fired at a low rate. Investments today in retrofitting existing plants to co-fire or building new co-firing or "conversion-ready" plants risk locking in carbon-intensive infrastructure and diverting finance from cheaper wind- and solar-based alternatives. Investments also extend continued economic reliance on coal supply chains in coal-producing regions, which presents a major challenge for a just transition. If co-firing is considered, transition finance frameworks should provide more clarity on timelines, flanking measures, and feasibility assessments, including assessing if there are better alternatives, both financially and environmentally (OECD, 2023b).

Air quality concerns

Co-firing with fossil gas, biomass, or synthetic fuels continues the pollution of fine particles from coal (i.e., lifecycle emissions from mining, production, transportation, and combustion) alongside the emission of other pollutants from the burning of the synthetic fuels or biomass, which can negatively impact air quality and human health. Coal combustion alone is responsible for 14% of premature deaths related to fine particulate matter (McDuffie et al., 2021). Myllyvirta and Kelly (2023) found that displacing 20% of coal with ammonia through co-firing would substantially increase ammonia emitted into the atmosphere, which could contribute to an increased formation of fine particles ($PM_{2.5}$). Exposure to $PM_{2.5}$ contributes to millions of premature deaths each year (Lelieveld et al., 2015). Because of their negative impact on human health, air pollutants are also linked to severe economic welfare losses (OECD, 2016).

$PM_{2.5}$ is chemically formed in the atmosphere from gaseous precursors including ammonia (NH_3), sulfur dioxides (SO_2) and nitrogen oxides (NO_x) (Heo et al., 2016).

Impacts on agriculture, forestry, and food security

High demand for biomass fuel raises biodiversity and deforestation concerns and can compete with land use for agriculture. It can promote monoculture cropping with negative impacts on biodiversity. Scientists warn that high demand for wood biomass creates a carbon debt where trees are cut down faster than they can be regrown to sequester the same amount of carbon released (Raven et al., 2021). This is a particular concern when primary forests are cut down as they are biodiversity hot spots and crucial carbon sinks. Biomass production can also negatively impact food security by competing for scarce land, labour, and water and can increase the price of staple food crops, which are also used as feedstocks (FAO, 2012).

Green hydrogen and ammonia production also raise concerns about environmental risks. The demand for renewable energy to power electrolysis often requires a large amount of land. Freshwater demands for production can also negatively impact water-stressed regions and could compete against agricultural water needs

/Λ 03

RETROFITTING: CARBON CAPTURE (UTILISATION) AND STORAGE

The Glasgow Climate Pact and more recently, the COP28 global stocktake text, call for the phase-down of unabated coal power, which leaves a loophole for continued coal exploitation through carbon capture and storage (CCS). In 2021, OECD countries agreed to prohibit export credit support for new unabated coal power generation technologies (OECD, 2021). However, they made an exception for new fossil fuel plants with CCS, and for support for pollution and carbon sequestration technologies for existing plants, as long as the plant lifetime is not extended or capacity increased (OECD, 2023a).

Feasibility concerns

Many countries plan on heavy use of CCS to achieve their climate objectives, particularly those with young coal fleets. However, the technology faces several technical and economic challenges and is not currently a commercially viable option and available at a scale that would meet the demand indicated in national planning. Most CCS deployed today is, in reality, carbon capture, utilisation, and storage (CCUS). CCUS partially addresses concerns about the lack of storage sites for CO_2 and high transportation costs but suffers from similar financial and technical challenges and, crucially, is often used to increase the production of fossil fuels like oil or gas. CCS and CCUS offer incomplete emission reduction and often do not address pre-combustion emissions.

In 2022, only 30 large-scale CCS projects were in operation globally, with more than 150 planned, mainly in Europe and North America (Steyn et al., 2022). Among operational projects, only a handful currently apply the technology to coal power plants – most apply it to fossil gas or oil (IEA, 2023a). Of the coal projects in operation, all utilise the captured carbon for enhanced oil recovery (i.e. CCUS).

The lack of commercial coal CCS plants is not for lack of trying. The United States alone have spent over USD 680 million on thermal coal CCS demonstration projects, which resulted in only one operational facility – the others were halted due to economic viability concerns (U.S GOA, 2021). The operational facility, Petra Nova, was shuttered after less than four years because of frequent shutdowns and volatile oil prices during the Covid-19 pandemic (Groom, 2020). The facility was reopened at the end of 2023 (Reuters, 2023). The U.S. Department of Energy considers Petra Nova successful despite its lower-than-expected capture rates. However, given the urgent need to reduce energy sector emissions, reliance on CCS for partial emission capture falls short when more effective alternatives are available.

Coal remains uncompetitive with renewable energy alternatives

Coal-fired power generation with and without CCS will continue to become increasingly uncompetitive in comparison to renewable alternatives. The levelised cost of electricity (LCOE) for thermal coal power generation with CCS is estimated at 1.5-2 times higher than current alternatives, when storage is excluded (Salt and Ng, 2023). In 2021, almost two-thirds of newly installed renewable power was cheaper than existing coal-fired power in the G20 (IRENA, 2022). Additional coal capacity risks low-capacity utilisation in the future as it becomes increasingly uncompetitive with renewables in many parts of the world. Investments in coal-fired power, with and without CCS, are highly susceptible to stranding and could strain the finances of debt-stressed countries.

CCS has not yet materialised as a viable large-scale decarbonisation option for the coal industry. It is expensive to install, offers incomplete emission reduction, and relies on government subsidies (Rempel et al., 2023). Despite significant investments, demonstration projects have yet to show promise as an emission reduction solution. CCS should not be used as justification to delay the retirement of existing plants or as a licence to build new coal capacity.

/Λ 04 FINANCING EARLY RETIREMENT WITH CARBON CREDITS

Retiring coal-fired power plants early and reducing their operations are critical steps to accelerate the decarbonisation of the global energy system. However, early retirement requires significant investments to facilitate the transition, which do not offer any direct financial returns. The sale of carbon transition credits associated with the emission reductions from early retirement is floated by some actors as a potential revenue source that can enable phase-out (Civillini, 2023). The credits aim to monetise the GHG emissions avoided by the early closure of coal plants and their replacement with renewable energy generation capacity. Proponents claim that carbon credits, each representing a tonne of CO_2 avoided, could provide a new revenue stream to close the funding gap for early retirement initiatives. However, financing early retirement with carbon credits presents several concerns both in terms of how emission reductions are determined and measured (their 'environmental integrity') as well as how offsetting claims associated with the credits offer buyers a licence to further delay cutting emissions elsewhere. These issues can threaten to undermine, rather than accelerate, climate ambition.

Concerns over the environmental integrity of 'coal transition' carbon credits

The environmental integrity of a carbon credit reflects the extent to which they represent emission reductions that are accurately and completely measured against an appropriate baseline of what would have happened in the absence of the revenues from the sale of credits. This quantification is inherently uncertain given the lack of perfect foresight on the impact of emissions in a counterfactual scenario (Fearnehough et al., 2023).

For coal transition credits to have integrity, the scheme needs to ensure that a number of critical conditions are met. A key criterion is to assure the **additionality** of emission reductions – i.e., the reduction in GHG emissions is additional to what would have occurred without the credit financing. This requires first deriving an estimate of the level of emissions in the absence of support from carbon credit markets - known as the baseline. Although there are existing and emerging new methods developed by carbon crediting standards to do this for coal plant retirements, they have been heavily criticised by researchers and NGOs, e.g. (Dufrasne, 2023). Existing and proposed methods to quantify the emission reductions associated with early coal retirement typically struggle to fully capture the dynamic effects of rapidly rising regulatory and political pressure to limit and end coal use in the power sector as well as the pace of renewable cost reductions, with clean alternatives already cheaper options than operating existing coal plants across a fast increasing share of the global coal fleet (Kachi et al., 2024). Strong contractual agreements like power purchase agreements (PPAs) might shield plants from these external factors to a certain extent and lock in coal generation and its associated emissions. However, plants operating outside of PPAs – for example those owned and operated by utilities - might be more susceptible to external factors and alter their retirement timelines without credits.

The emissions reduced from early retirement are at a high risk of being displaced elsewhere in ways that are hard to measure, known as **leakage**. In energy systems with excess capacity, the early closure of one plant could boost profitability and lead to a higher capacity factor at another coal plant if the electricity generation is not replaced with a similar renewable capacity. This is a particular risk in countries like Indonesia and India, where their coal fleets operate at capacity factors well below their technical potential.

To address leakage, proposed methodologies outline eligibility criteria for renewable plants that could replace retired capacity. Concerningly, the proposed carbon credit methodology by the Coal to Clean Credit Initiative considers biomass-fired power plants as eligible paired renewable generation capacity (Coal to Clean Credit Initiative, 2023). As outlined in section 2 above, there are a number of material issues associated with replacing coal generation with biomass. There should also be consideration of the proposed retirement timelines and whether they align with IEA guidance of coal phase-out by 2030 in developed economies and by 2040 in emerging markets and developing countries (IEA, 2021). Credits should be reserved for those with accelerated retirement timelines and avoid rewarding plants that present retirement timelines that are misaligned with the Paris Agreement.

Another critical requirement to uphold the environmental integrity of carbon credits is to avoid **double counting of the same emission reductions**. There are different forms of double counting the avoided emissions represented by a carbon credit, but a critical one in this context is to prevent more than one entity 'double claiming' the outcome. If a carbon credit buyer purchases credits and uses them to offset their own emissions, claiming the reduction for their climate strategy, those emission reductions cannot be simultaneously accounted towards achieving a national target (e.g., a Nationally Determined Contribution, or NDC). The Paris Agreement's Article 6 – which establishes a set of rules for accounting for carbon credits – includes provisions for adjusting NDCs where carbon credits are sold and used for offsetting purposes, known as "corresponding adjustments". However, the infrastructure to implement these provisions remains limited today and voluntary carbon standards, which may offer coal retirement carbon credits are not necessarily bound by these rules. In addition, even if corresponding adjustments are implemented, they are only effective if the country has an ambitious overall NDC, such that the sale of credits forces the country to take additional action elsewhere to cut its national emissions. Given that reducing coal generation emissions is typically one of the cheapest abatement options available to countries, applying a corresponding adjustment for coal transition credits is likely to simply raise the cost of meeting existing national climate targets, increase the likelihood that the targets are not met, or lead to no overall change in the countries' emissions profile (Fearnehough et al., 2020).

Carbon credits used for offsetting risk transferring a licence to emit elsewhere

If carbon credits issued for early coal retirement are used by buyers to support claims to offset, or 'neutralise' their emissions, there is a risk that the credits directly delay urgently needed climate action elsewhere. This 'substitution effect' can undermine global decarbonisation efforts because in return for cutting emissions from coal plants in the electricity system where credits are issued, they facilitate weaker climate action within the value chain of the carbon credit buyer by offering a license to pollute (Fearnehough et al., 2023). The overall effect on the global stock of GHG emissions may be negligible and, in some circumstances emissions could even increase, particularly where the credits lack environmental integrity (Fearnehough et al., 2020). This criticism holds for carbon credits originating from any type of emission reduction, avoidance or removal approach and is not specific to early coal retirement. However, despite these concerns, private sector led initiatives such as the Energy Transition Accelerator, which is aiming to mainstream carbon crediting for cutting electricity sector emissions, with a focus on coal, do not explicitly prevent credit buyers from using them to claim to offset their emissions in their proposed framework to date (U.S. State Department et al., 2023). If carbon credits are used as an instrument to finance early retirement of coal plants, to ensure they have the climate impact they report to, it is critical that they are not simply a vehicle to transfer emissions to other countries or sectors. Carbon credits for early retirement should therefore not be used to substantiate offsetting, or neutralisation claims.

/Λ 05 CONCLUSION

There is an urgent need to transition away from coal-fired power plants to achieve climate objectives and avoid the worst impacts of climate change. Public development banks should exercise caution in engaging with coal phase-down to avoid setting perverse incentives that might extend plant lifetimes, offer incomplete emission reductions, and shift focus away from early retirement. Solutions that advocate cutting emissions while still relying on coal usage represent false solutions that fail to address the urgency of the climate crisis and as a result the risk of asset stranding or the imperative for early retirement. False solutions divert limited climate finance, presenting a high risk of delaying the transition.

Public development banks have the potential to facilitate the transition from coal to renewable alternatives in developing and emerging countries by fostering conditions conducive to early retirement and repurposing. This support could include enhancing regulations related to GHG emissions, air pollution, and electricity market design, supporting the design of tax incentives, and providing financial backing to facilitate early retirement. The challenges and risks associated with the early retirement of coal plants are further explored in the accompanying report Financing coal phase-out: Public Development Banks' Role in the Early Retirement of Coal Plants (2024), which examines the role of public development banks in collaborating with national governments, utilities, and independent power producers.

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