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The Economics of Coal Phaseouts: Auctions as a Novel Policy Instrument for the Energy Transition

Sugandha Srivastav and Michael Zaehringer

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Auctions as a Novel Policy Instrument for the Energy Transition

By Sugandha Srivastav* and Michael Zaehringer

*sugandha.srivastav@smithschool.ox.ac.uk

Abstract

Fossil fuels are the world's greatest source of greenhouse gas emissions and must be curtailed to achieve temperature targets. Due to political-economy constraints, carbon pricing is unable to internalise the social cost of carbon and compensation for the early closure of coal-fired power plants may represent a more politically feasible route towards achieving desired temperature targets. Compensation decided via a negotiated approach suffers from asymmetric information and rent-seeking. Competitive auctions can help discover the true cost of power plant closure and effectively ration remaining coal towards uses with the highest value. However, successful auctions require considering: 1. additionality and interaction with existing climate policies, 2. dynamic incentives, and 3. system-wide effects and security of supply. Since Germany is the only country till date to have implemented a coal phaseout auction, we use it to analyse the merits and demerits of the policy. In the absence of being able to implement an auction, strengthened incentives for scrappage and repurposing of coal assets could be options.

Policy Insights

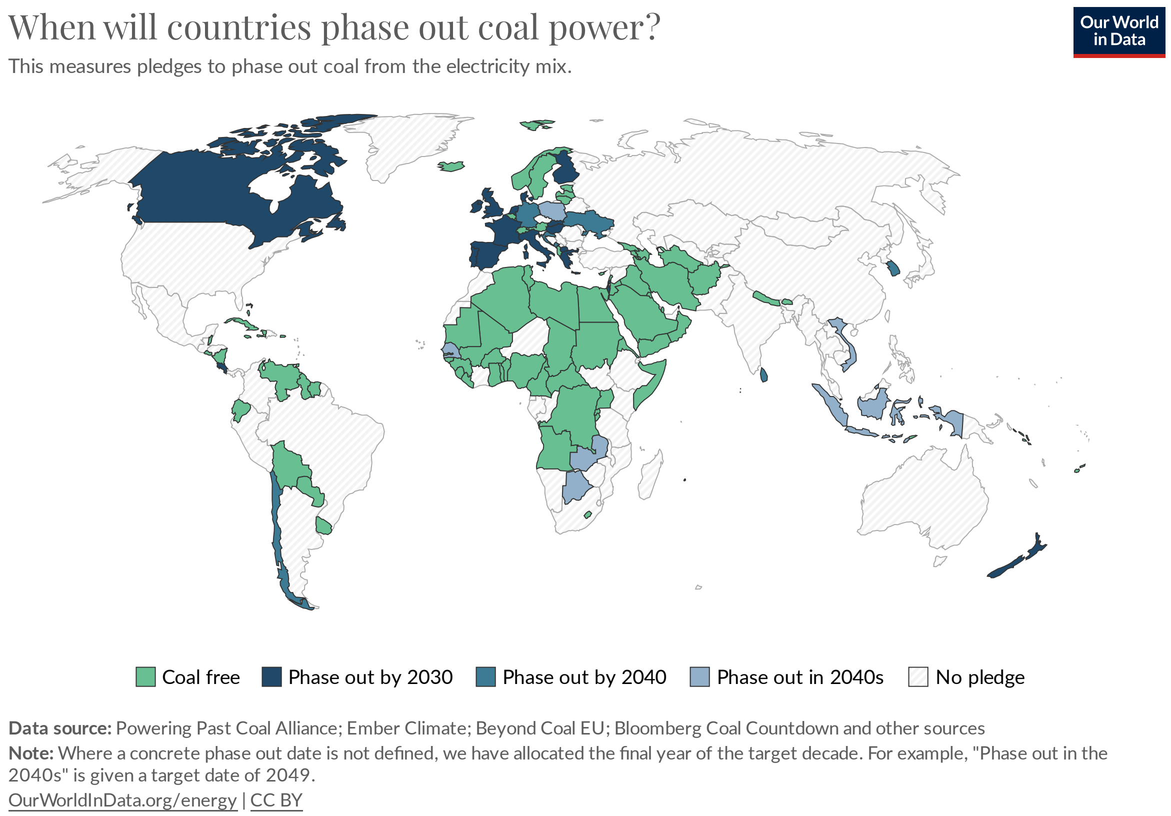
1. Compensation for early closure may be a politically feasible alternative to "polluter-pays" policies such as carbon pricing.
2. Competitive auctions can deliver efficient compensation payments for early coal closure relative to a negotiations-based approaches which suffers from asymmetric information and rent-seeking.
3. Supply-side policies such as retiring emissions allowances in line with the coal phaseout can help mitigate carbon leakage risk.
4. Careful consideration around dynamic incentives, local market structure, and system stability is needed to ensure that the auction induces competition and delivers efficient outcomes.
5. Policies such as strengthened incentives for scrappage and repurposing of coal assets may be suited to contexts where auctions are deemed infeasible due to high levels of market concentration.

Keywords
Coal phaseouts, auctions, asymmetric information, compensation, climate policy, net zero, Germany

Introduction

A net zero future cannot have unabated coal. Fossil fuels are the world's greatest source of greenhouse gas emissions. There is already enough fossil fuel energy in the system that if these assets are operated until the end of their economic lifetimes, the world would breach the 2-degree temperature target set by the Paris Agreement (Tong et al. 2019). Coal combustion accounts for 40% of annual emissions from energy and industry, and is the most carbon-intensive form of energy generation (Andrews and Peters, 2022). Many countries have consequently put in place coal phaseout targets (Fig 1).

Figure 1: Coal phaseouts



A commonly discussed approach to addressing climate change is to put a price on CO_2. A carbon price is "technology-neutral" since it does not tell agents how to cut down on emissions (they are free to replace fossil fuels with renewable energy, increase energy efficiency, or stop a certain activity altogether). A carbon price is theoretically "first-best" as it can lead to the discovery of least cost abatement strategies thanks to its non-prescriptive nature and singular focus on penalizing the pollutant. However, the mean value of the social cost of carbon from expert analyses is $500/tCO2 (Moore et al. 2023), and there is not a single carbon pricing scheme in the world that has come even close to this value (World Bank 2023). Consequently, it is unsurprising that existing carbon pricing schemes are unable to deliver coal power plant closures at the necessary speed and scale. Due to the reality of being in a "second best world", there is an "opportunity space" to consider multiple policy instruments to achieve climate goals (Lipsey and Lancaster 1956; Jenkins 2014).[1] Therefore, across jurisdictions we simultaneously see carbon pricing alongside technology-specific measures such as fuel efficiency mandates for cars, gasoline taxes,

[1] This is also rationalised by the presence of multiple market failures (e.g. Jaffe et al 2005).

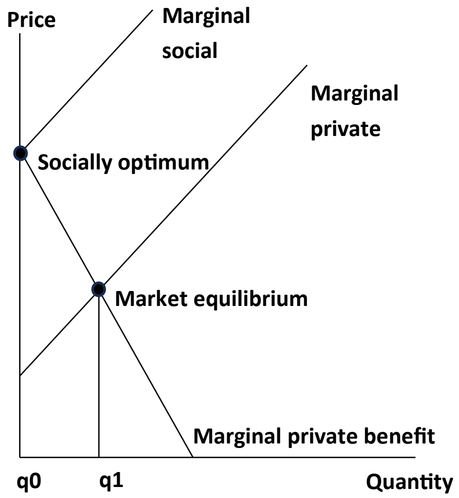
building regulations and feed-in tariffs for renewable energy (Jenkins 2014; Vogt-Schilb and Hallegatte 2017).

There are also pragmatic reasons why technology-specific policies are implemented. If there is no measurement infrastructure to track CO_2, a feasible alternative is to target a close proxy such as coal combustion, which is easier to measure. Even in jurisdictions with measurement infrastructure, explicitly tracking fossil fuel infrastructure like coal-fired power plants and combustion volumes is a transparent way to create greater accountability while focusing only on net CO_2 requires elite carbon accountants who are subject to regulatory capture and lobbying by vested interests (Green and Kuch 2022). This risk is non-trivial as illustrated by the unravelling of the carbon offset market in which has large volumes of offsets with no additionality (Cullenward and Victor 2020).

A coal phaseout target could also be rationalized on the grounds that coal combustion has negative environmental and societal impacts beyond CO_2. This includes soil and water pollution, SO_2 emissions, fine particulate matter, habitat degradation and negative health impacts. Taxing these externalities separately has the advantage of incentivising coal to be "cleaner", for example, by installing pollution control equipment or locating away from high-value ecosystems but in practice, there are major hurdles towards a credible system of Pigouvian taxation or even Coasian bargaining for natural capital (Teytelboym 2019; Deryugina et al. 2021).[2] If the sum total of these externalities imply that the "optimal quantity" of coal in the system is tending towards zero (Fig. 2), one could economically justify a phaseout, similar to how other pollutants have been regulated out in the past.

There is also, increasingly, a moral call to end fossil fuel use as witnessed by the Pope's statements at COP28 (Ware 2023). This is not dissimilar to how economists have ceased to question the level of optimal warming (Nordhaus 1993) and have re-oriented efforts to find the most efficient way to reach externally set temperature targets. One could similarly argue that economists must now think about how to ration the remaining coal towards the uses with the highest value without second guessing the "optimal" quantity of coal in the system.

Figure 2: The economic rationale for a coal phaseout



[2] Natural capital is heterogenous, measurement of impacts is challenging, transaction costs are high and there are ecological complementarities. These characteristics contribute to the practical difficulties in internalising the externalities through market-based schemes. For Coasian bargaining, a challenge is the multiplicity of agents who are affected by pollution and ensuring that in the process of allocating property rights, and subsequent bargaining, all of these interests and values are accurately captured. If they are not, the outcome will not be efficient.

Finally, since coal phaseouts relate to discrete and highly salient outcomes that are more tangible than outcomes such as reducing CO_2/GDP (Collier and Venables 2014, Erickson et al 2018), they might be useful for virtue signaling amongst a climate-conscious electorate or in international climate forums where high-income countries are expected to contribute relatively more to climate change mitigation.[3] Questioning the social license to operate polluting assets such as pipelines, mines or powerplants has already seen significant levels of political mobilization around the world (Piggot 2018), and a politician may use this strategically to maximise the "perceived" welfare of their electorate (Srivastav and Rafaty 2023).[4] Compensation for early closure might represent a more acceptable pathway than punitive policies for the constrained policymaker that is balancing industry interests and investor protection against climate aims and impact on government budgets.

Notwithstanding the various arguments in favour or against a technology-specific policy, this piece takes as a given the science-based imperative to phase out unabated coal combustion and focuses on how compensation for early closure can be implemented in a manner that is efficient. We explore when an auction-based approach is appropriate, how to ensure additionality, appropriately manage dynamic incentives, and think through system-wide effects.

Background

Phaseout policies need to restrict the growth of new fossil fuels and expedite the retirement of the existing stock. While there are a variety of policies that one could achieve the former, (Lazarus and van Asselt 2018), the latter is more complicated as it may require breaking existing long-term contracts, conflict with investor protection norms and cause issues with security of electricity supply. Compensation for early closures is a "pay-to-break" mechanism that accounts for the costs of prematurely winding down coal-fired power plants.

Closing down coal-fired power plants early involves various costs: severance packages need to be paid to workers, early termination fees are required if contracts are broken prematurely, and polluted waterways or soil need earlier rehabilitation. Furthermore, in cases where power plant closure is not due to market forces (which could include a carbon tax), then there also needs to be a payment to reflect the opportunity cost of closure, that is, the net present value (NPV) of the future stream of profits that would have otherwise occurred. The opportunity cost can vary significantly by power plants based on where they are located, whether they supply to the grid or are engaged in captive generation, their efficiency, and the extent of renewable energy uptake in the area.

It is difficult for a policy-maker to know, ex-ante, what the opportunity cost of closure is and it is this informational challenge, that makes auctions for compensation an important policy lever. Owners of coal-fired power plants have an incentive to overstate closure costs while governments, considering taxpayer interests, seek to achieve low-cost closures. An auction with enough competition between power plants, can lead to the discovery of "true" closure costs. Since the amount of compensation is scarce relative to the number of coal plants bidding for it, power plant owners have an incentive to disclose their true costs (if they overstate, they risk losing the auction and exiting with no compensation, if the understate, they similarly incur losses). By contrast, in bilateral negotiations there is a strong

[3] High income nations are have already begun establishing vehicles to fund for plant closures in developing nations. An example is the "Just Energy Transition Partnership" in Indonesia in which "20 billion USD [will be mobilised] …to help phase out coal energy and invest in renewable energy infrastructure" (UK Cabinet Office 2022).

[4] Even if targeting specific infrastructure is more costly, there is a discrepancy between perceived and actual welfare amongst the citizenry (see model in Srivastav and Rafaty 2023). Examples of high levels of mobilisation around polluting infrastructure include opposition to: the Keystone XL pipeline and the expansion of the Hambach open-cast coal mine in Germany (Rafaty et al 2020).

incentive for the power plant owner to exploit information asymmetry and overstate their opportunity cost of closure to secure greater compensation. If there is a lack of competition, however, the advantage of an auction can break down leading to speculative bidding or collusion.

1. Auctions, negotiations and other incentives: when to use what policy

Based on the local context, the design of a coal closure auction should ensure enough competition by calibrating the geographic scope, reviewing the eligibility criteria, deciding if the auction is broken into multiple rounds or not, and by thinking about the diversity of players (including their ownership structures). If there is an assessment that no auction design can stimulate enough competition, which might be the case in highly concentrated markets, measures such as strengthened incentives for scrappage and/or repurposing of coal assets (e.g., by switching to biomass), (ii) removal of fossil fuel subsidies and (iii) coal taxation or cap-and-trade schemes to restrict tonnage of coal combusted may be better suited, if there is a political will to expedite the decline of coal. A negotiated approach to compensation payments for early retirement could also be considered but this would require carefully managing the information asymmetry.

In other contexts, where coal-fired power plants are publicly owned, and there is an impetus to internalise the social cost of pollution, the relevant public authority can simply optimise like a social planner and there is no need for market-based instruments. For example, in Ontario, where coal went from constituting a quarter of total supply in the early 2000s to 0% by 2014, the phaseout strategy had a command-and-control nature since all of the remaining coal-fired power plants were owned by a provincial body, Ontario Power Generation (OPG) (Winfield and Saherwala 2022). OPG wrote off whatever residual capital value remained in the power plants to help facilitate closure, while the government and grid operator managed the power system through the installation of new natural gas plants and nuclear power (Winfield and Saherwala 2022). The plan for a total phaseout was motivated by concerns around smog, acid rain, and heavy metal pollution (Winfield and Saherwala 2022). Since the province had complete control, there was no principal-agent problem and the social cost of pollution was internalised through a mandates and moratoriums.

However, in many contexts around the world, coal-fired generation is privately owned and problems of information asymmetry and misaligned incentives are rife. This setting requires different strategies (see Table 1). Alberta, which in 2015 decided to phaseout coal, had to set aside a little over 1 billion Canadian dollars to compensate coal power companies (Vriens 2018). This involved negotiations with three major companies. Given the level of market concentration, it was infeasible to run a competitive phaseout auction. In Chile, there is similarly limited competition and an incentive scheme was created to scrap the coal asset and in return, get a loan to build out renewable energy infrastructure (Climate Investment Funds. 2021).

In other markets there is both private ownership and enough diversity to think about auctions. It is for this reason that Germany considered a novel approach for its hard coal phaseout. Introduced in 2020, the German Coal Exit Act allows hard coal power plants to voluntarily exit between 2020 and 2026 and compete in auctions for compensation payments (Tiedemann and Müller-Hansen 2023). Coal power plants submit sealed bids stating their compensation amounts in €/MW of installed capacity. The government ranks bids in descending order and selects the most cost-effective ones until the total budget for compensation payments is exhausted. From 2027, decommissioning can be mandated without compensation and by 2038, all coal plants need to retire.

Since Germany is the only country in the world till date to have implemented a coal phaseout auction, we use it to analyse the merits and demerits of the policy, with an acknowledgement that more evidence is likely needed to establish the feasibility of such a scheme and not all lessons will be transferable across contexts. Yet due to the nature of policy formulation and adoption, there is an imperative to understand the lessons that can be drawn from the first use-case of a coal phaseout auction, especially because there are other contexts with both private ownership and sufficient competition. The subsequent sections will draw heavily from the German case.

Table 1: Coal phaseout strategies in select jurisdictions

Region	Privately-owned coal companies	Strategy	Rationale
Ontario	✘	Write-off value	Aligned incentives since coal plants publicly owned
Alberta	✓	Negotiated compensation	Private players, insufficient competition
Germany (hard coal)	✓	Auction-based compensation	Private players but sufficient competition
Germany (lignite)	✓	Negotiated compensation	Private players, insufficient competition
Chile	✓	Incentive to scrap coal and re-invest in renewable energy	Private players, insufficient competition

2. Ensuring additionality

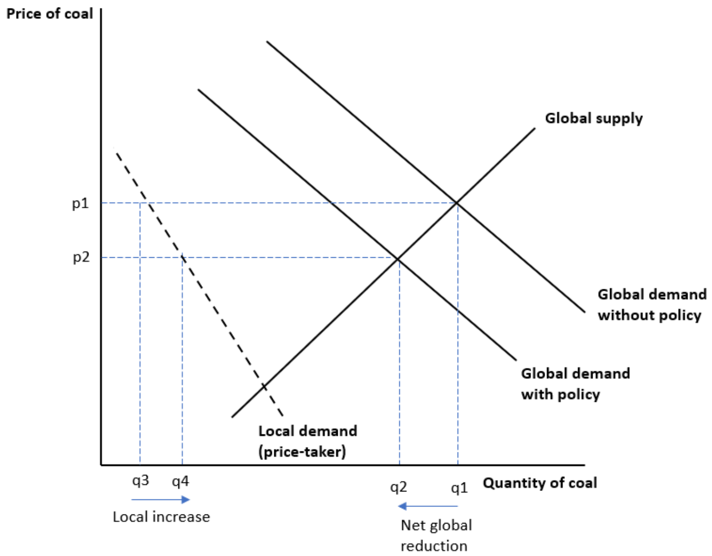
A core challenge for any coal closure scheme is to ensure *additional* emission savings which would not have occurred otherwise, or which are not offset by higher emissions elsewhere. In a negotiated approach, it is difficult to ascertain if the coal power plants asking for compensation was going to wind down anyway. Due to cheap renewable energy, many coal power plants are becoming economically unviable. In Australia, this is creating economic pressure to retire coal-fired power plants ahead of schedule (Jotzo et al 2018), as evidenced by a plant shutting down a decade ahead of its scheduled closure (Turnbull 2022). A competitive auction can theoretically reflect the opportunity cost of closure by getting lower bids from power plants with shorter economic lifetimes. Several additional steps can be taken.

First, winding down operations can take a long time and there is a risk that if the lead time for decommissioning is too short, only those bidders who have already planned to mothball or decommission their plant participate in the auction. In the first German auction round in 2020, the lead time was only one month from the date of award until the end of operations, raising concerns that payments were given to power plants which were already planning for closure.

A second concern is that the retirement of coal can interact negatively with other climate policies. In Germany, coal retirement carries the risk of creating a "waterbed effect" in the EU ETS. Usually, coal-fired power plants demand permits to emit CO_2 but the gap in demand created by their closure at constant supply of CO_2 certificates would cause EU ETS prices to fall, leading to increased emissions elsewhere (Akerboom et al 2020). To address this, the German government announced it would cancel an equivalent amount of CO_2 certificates.[5]

There is also a risk of international leakage, where restricting coal combustion in one area may result in an increase in coal combustion in other areas that is not under similarly stringent climate policy (Fig 3). This "leakage" can be offset by restricting coal supply (Asheim et al. 2019). A carbon border adjustment mechanism can also achieve a similar effect by creating an incentive for non-complying areas to implement more stringent climate policy (Helm et al. 2012.). In many cases, coal markets are not integrated ruling out the possibility of leakage (in this case, there are individual supply curves for each region rather than a global supply curve). For example, German lignite and Indian coal have sufficiently low energy densities such that it is uneconomic to transport these resources large distances.

Figure 3: The risk of leakage



Note: demand-side policy can reduce global demand for coal (q1 → q2) but in price-taking jurisdictions with no policy, the resultant fall in global price (p1 → p2) can increase local consumption (q3 → q4). The overall fall in global demand would be higher if these jurisdictions also adopted climate policy. Shifting global supply to the left can help counter leakage (i.e. q3 → q4) and achieve higher net global reduction.

3. Dynamic incentives

Germany's coal phaseout auction is broken into multiple rounds over time. While a staggered phaseout has the advantage of giving the system time to adapt, it may also create strategic considerations amongst

[5] Based on modelling around how many carbon permits these power plants would have demanded.

bidders. For example, there may be an incentive to be "the last one standing". If electricity demand is growing and renewable expansion cannot keep apace, then expected profits for the last coal power plants are higher. Coal power plants will internalize this dynamic and reflect it via bids. However, too much strategic waiting can create a lack of competition that undermines the efficiency of earlier auction rounds.

To ensure enough competition in earlier rounds, auction rules can penalize late-movers. Three ways of doing this from the German case include (i) decreasing the maximum possible compensation amount over time, (ii) instating an end rule such that closures after a certain date are mandated without compensation (in Germany this is 2027), and (iii) imposing penalties for lack of participation (if there is undersubscription in a German auction round, the oldest coal power plants must close down without compensation).

There is a concern amongst some that compensation creates moral hazard, where if it is known that there will be payments for early closure, coal-fired power plants will enter the market opportunistically. However, this is unlikely for two reasons: first, in most jurisdictions there is no economic case for new coal or new plants are prohibited (such as in Germany). Secondly, a new power plant will need relatively high compensation relative to existing power plants, making it more likely to lose the auction (another reason why auctions are superior to negotiations). Finally, since there is an end date by which all coal must exit the system without the compensation, the room for strategic or opportunistic entry is further limited or sometimes simply banned by law.

Further, power plants remaining in the market could be mandated to fund the compensation for early closure in proportion to their CO_2 emissions (Jotzo and Mazouz 2015). This acts as a penalty for staying longer in the market and adheres to the polluter pays principle. There is a risk that since it creates costs for coal investors, they may challenge the policy in court. This happened in the case of Germany's nuclear phaseout where the government was straddled with several costly litigation cases afterwards and was also one of the reasons Alberta had to compensate its coal companies (Winfield and Saherwala 2022).

A potentially more sophisticated and flexible approach would be to allow for menu bids that let coal plants signal individual decommissioning costs for different decommissioning dates through their bids (Riechmann and Zaehringer 2020). In this case, the auctioneer invites bids for different decommissioning dates for a certain deadline, for example, in 2020 for closure in 2021 to 2028, aligned with the target path for the coal phaseout. This would allow plants with long lead times (such as coal plants with heat output that is often under a long-term contract) to also compete, thereby bolstering participation. This can help determine combinations of closure dates that fulfill the target path and minimize total compensation payments. It also maintains a phase approach that is more conducive to system stability.

4. System-wide effects

In power markets, early closure of coal plants can have system-wide effects, both from a grid and overall market perspective. Bids should be able to reflect scarcity and the role each power plant plays in the power system. However, some power plants may have positive externalities because they serve as a critical node in the electricity network and help manage congestion. Externalities linked to congestion will not show up in individual bids as they relate to the system rather than the coal power plant. Design adjustments in the auction can ensure that critical assets are not decommissioned prematurely. In Germany, southern coal-fired power plants were not allowed to participate in the first auction due to system stability concerns. Subsequently, when these were allowed to participate, a "penalty" was applied on top of their bid to reflect the higher system costs of their closure. The German power regulator could also decide if these power plants were to be kept as reserve capacity.

The auction design should also incorporate some flexibility given the potential for crises in the power market. The progressive decline in German bid caps (which specify maximum compensation) which were set in 2020, turned out to be incompatible with the market situation which prevailed after the Russian invasion of Ukraine (Riechmann et al. 2023). The 2020 bid caps prevented scarcity signals from being reflected via higher bids for coal closure. This impeded the ability of the auction to deliver efficient decisions (Riechmann and Zaehringer 2020, Riechmann et al. 2023).

Relatedly, the German government had to retrospectively allow plants that stopped operations to re-enter the market. As of 9th January 2023, there were 12 power plants, with a total capacity of 4,166 MW (40% of total procured capacity), that have declared their temporary return to market. This particular crisis was extreme. However, it underscores the importance of maintaining some degree of flexibility and complementing coal phaseout programmes with complementary policies that seek to expand clean energy generation and demand-side management.

5. What to auction

There is also a question of *what* to auction. The optimal would be to consider avoided future CO_2 emissions. However, in practice, this is a difficult metric to assess. Instead, auctions could consider coal capacity or generation. The latter is preferable. In Germany, the hard coal auction solicited bids in terms of €/MW (of installed capacity) and divided these by CO_2 (averaged over the last three years) to produce a rank order. Modern plants tend to have higher CO_2 per nameplate capacity (MW) because they are run more often but their CO_2/MWh is lower since they are more efficient. However, since capacity - rather than generation - was considered, two-thirds of the quantity selected for early closure in the first auction round belonged to modern power plants (Riechmann & Zaehringer 2020). The auction should aim to find least cost abatement in terms of €/CO_2 and look at CO_2/MWh to ensure efficiency is adequately taken into account.

Where measurement of CO_2 emissions is difficult the auction could consider tonnage of coal as a proxy. This would have to draw distinctions between coal that is more polluting by looking at the grade of coal. An alternative technology-specific approach could be a cap-and-trade system for tonnage of coal (Riechmann et al. 2023). The government would set a cap on the remaining tonnage of coal which can be burnt and permits representing tonnage of coal would be created and traded. More efficient plants would be able to reduce coal input and sell permits, while less efficient ones would have to incur the costs of buying these. While tonnage of coal is an imperfect proxy for CO_2, it may be advantageous in areas without monitoring infrastructure. A cap-and-trade scheme may also work with very few operators (in contrast to an auction). It also follows the 'polluter pays' principle where coal power plants instead of taxpayers have to pay. This is useful in settings where governments are budget constrained and would benefit from the tax revenues. However, there may be distributional effects: if allowances are grandfathered, then the largest polluters get relatively more allowances which may be perceived as unfair and coal power plants may legally contest the idea of introducing artificial scarcity.

There is 30 years of experience with emissions trading systems word-wide which shows that cap-and-trade systems, if designed well and appropriately implemented, can achieve targeted emissions reductions cost-effectively (Schmalensee & Stavins 2017). Coal-phase out, with its narrow focus on a single technology, might easier to design than the far more complex emission trading schemes as the EU ETS.

Conclusion

For those contexts where it is possible to run competitive auctions, then such measures will be superior to negotiated buyouts that suffer from asymmetric information and increase total compensation costs. With the difficulties in implementing polluter-pay policies, there is a need to consider alternatives, especially as the world risks tipping into points of no return vis-à-vis the climate crisis. In countries with domestic coal resources, such as South Africa, India, Australia and Turkey, asset owners, workers' unions, local banks, and even state-level exchequers are highly exposed to the coal sector and are concerned about where a rapid transition would leave them. The influential nature of these groups can be seen repeatedly through the "short-circuiting" of climate policy (Stokes 2020). Given the time-sensitive nature of the climate crisis, compensation may pass the public cost-benefit calculus even if it does not adhere to the polluter-pays principle.

There is also a case to be made for compensation in the spirit of "just transition", where key costs include those related to rehabilitating coal workers and lands. Unless coal-dependent communities are compensated in the wake of large power plant closures, there is a risk that they will get increasingly marginalised and politically polarised, which can lead to detrimental impacts in terms of social cohesion (Heal and Barry 2017). Mandating that the owners of coal-fired power plants to pay out proper severance packages to laid-off workers and rehabilitate the land is an important factor towards ensuring a smooth transition. In Germany, the coal phaseout scheme earmarked funds for workers and coal-dependent regions to help in reskilling and redevelopment.

There is also some early-stage thinking on how coal phaseout auctions could be used to tackle climate equity issues across countries. The Asian Development Bank's Energy Transition Mechanism is considering using funds garnered from the Global North to help wind up coal assets in the Global South and deploy auctions to facilitate the discovery of true closure costs but as Table 1 illustrated, much depends on local context to assess which phaseout strategy is best and international transfers require deeper political-economy considerations.

Where coal-fired power plants are publicly owned and there is a public impetus to internalise the social cost of pollution, then simple mandates and closures can proceed in a command-and-control fashion, given there is no "market" to regulate in the first place. This was the case of Ontario, where the province optimised like a social planner. In places where coal-fired power plants are privately owned but there are only a very limited number of players, who are likely to collude, then strengthened incentives for scrappage and repurposing of assets may have an important role to play and may offer an alternative to negotiated compensation schemes (see Chile, Table 1).

Finally, in markets where coal-fired power plants are privately owned and there is plentiful competition, then auctions provide way to ensure that the compensation to each plant reflects to true opportunity cost of closure. In these contexts, the auction design should be sensitive to concerns around additionality, dynamic incentives and system-wide effects.

Ultimately, compensation for early closure is an important policy lever when carbon pricing itself is unable – for the most part – to deliver the politically and ecologically required rate of coal closures and climate change itself embodies a grave concern for global equity and justice. Coal is the world's most polluting energy resource and there is a growing consensus that unabated coal has to be eliminated from the energy system. The task is less so around finding the "optimal" quantity of coal in the system, and instead, more about how to reach externally-imposed closure targets with compensation that reflects the true opportunity cost of early retirement, minimises rent-seeking, and which explicitly prices in rehabilitation to workers and degraded lands. An auction, we argue, is well suited for this purpose as long as it can be designed to be competitive.

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Author information

1. Smith School of Enterprise & the Environment, Department of Economics, Institute of New Economic Thinking, University of Oxford, United Kingdom

   Sugandha Srivastav

2. Frontier Economics, Cologne, Germany

   Michael Zaehringer

Correspondence to Sugandha Srivastav (sugandha.srivastav@smithschool.ox.ac.uk)

Ethics declaration

The authors declare no competing interests.
Michael Zaehringer works at Frontier Economics but views expressed are of the individual and do not reflect that of Frontier Economics in any form.