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Trade-offs in the Energy Transition: Local Public Health Gains and Socioeconomic Costs of U.S. Coal Facility Retirements

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Abstract. Retirement of coal-fired power stations and industrial coal plants is a crucial characteristic of the US energy transition process. While reduction in fossil fuel consumption provides climate and air-quality benefits nationwide, local communities hosting these facilities face uneven socio-economic, fiscal and public health outcomes. This paper analyses local socio-economic and public-health consequences of US coal-related facility shutdowns from the perspective of negative externality environmental economic theory and with the help of comparative case studies of Huntley Coal-Generating Station and Shenango Coke Works. By using peer-reviewed scholarly literature and secondary empirical evidence published in governmental reports, the paper aims to address two main research questions. First, what is the mixture of benefits and concentrated local costs of coal infrastructure shutdown? Secondly, what makes it so hard to prove the empirical link between environment policy, environmental conditions in the locality and health results and what case study evidence can be gained from a natural experiment?

Keywords: coal plant retirement, energy transition, negative externalities

1. Introduction

Coal consumption brings considerable hidden costs which are not accounted for in the market price [1]. These externalities include premature mortality, childhood respiratory disease, local water contamination and climate change. These costs fall predominantly on local communities which are in the vicinity of the plant. During the last two decades, hundreds of coal-burning and coal-linked facilities in the United States have been permanently shut down owing to lower costs of alternative energy sources, stricter federal and state regulations, renewable portfolio standards and corporate de-carbonisation commitments. While this process creates a welfare increase for the country and for the planet, the place-specific transition risks emerge.

Most of the existing literature considers transition as welfare-improving and discusses the aggregate environmental and health benefits. However, little attention is paid to the distributive nature of the transition costs which are concentrated in a few specific communities [2]. This paper contributes to the literature by using environmental economic theory and comparative case studies to analyse both positive and negative consequences of coal infrastructure shutdown. Peer-reviewed

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academic papers, governmental regulatory documents and secondary empirical evidence are used along with two case studies of actual shutdowns: Huntley Coal-Generating Station in New York and the Shenango Coke Works in Pennsylvania [3].

Another research question addresses why it is empirically challenging to identify direct causal relationships between environmental policy and local environmental conditions, and what can be learned from natural-experiment case studies in terms of overcoming this challenge. Shutdowns are seldom isolated events; they go hand in hand with other factors like economic restructuring, migration and changing environmental regulation which complicates the causal attribution [4]. Shutdowns offer a limited natural-experiment approach to local impacts isolation.

2. Background and theoretical framework

Since the early 2000s, the U.S. electricity generation sector has experienced a significant restructuring of coal capacities. Plant closures are driven by a combination of different factors. Market forces play an essential role: cheap natural gas and declining cost of renewable energy sources diminish the economic viability of coal units [5]. Increased federal and state environmental regulations restrict mercury, particulate matter and other air pollutants, increasing compliance cost for ageing facilities and requiring expensive upgrades for them. Corporate climate commitment and increased investor pressure make utility companies decommission their coal assets prematurely before their technical life comes to an end.

Not all coal-related closures happen because of environmental policy. Industrial coal infrastructure like coke plants may be shut down owing to fluctuations in global commodity markets, changes in supply chains or decreased demand in steel manufacturing industry. It is necessary to make a distinction between these two categories because when a facility is shut down as a result of market shock rather than environmental regulations, it creates a better ground for a natural experiment separating pollution reduction from other concurrent policies.

Facility shutdown creates dual consequences for the host communities. On the one hand, reduced emission rate decreases local ambient pollution rate, resulting in lower prevalence of asthma, cardiovascular hospitalisations and mortality [6]. On the other hand, shutdown reduces tax base for the city which faces difficulties with providing public services. Job losses in coal sector may also affect other local businesses. Brownfield liability remains a costly issue after a coal closure.

Environmental economic theory treats fossil fuel consumption as a negative externality. Consumers and producers face private costs of the product and pollution, whereas third parties who are not involved in the initial transaction incur pollution damage. Thus, the introduction of corrective environmental policy in form of a Pigouvian tax makes it possible to incorporate external costs into the price, aligning it with social cost and decreasing pollution efficiently [7, 8].

Whereas environmental regulation can solve the problem of the market failure due to fossil fuel externalities, badly drafted regulations may have overregulation as their downside. As can be seen from Figure 1, the welfare loss may occur when there is overregulation. In case when the standard of the environment is established at the level of point C (which is far beyond the optimum level), then marginal cost of producing further improvements in environmental quality will outweigh marginal benefit (MB_2). The model described above is very applicable to the policy of coal transition in the USA as it concerns clean energy mandates.

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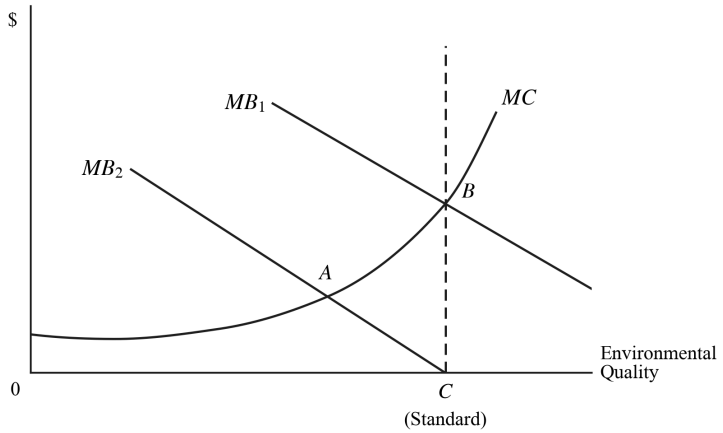

Figure 1. Welfare loss from setting incorrect environmental standards (adapted from [7])

The standard framework for externality analysis tends to concentrate on the total welfare. It fails to account for the distributive aspect of this issue, which is discussed in the contemporary transition literature. There are new negative externalities that emerge in the course of transition: transition-related externalities include municipal revenue loss, stranded infrastructure and unemployment in coal sector [2]. While the total welfare increases, some particular communities or workers may experience net losses unless there are any compensation schemes. This is the core justice issue related to the energy transition: efficiency does not imply equity [9].

Creation of an empirical link between plant closure and its consequences faces a number of challenges. Firstly, effects of health deterioration due to the influence of air pollution manifest themselves over a long period of time. Health issues related to increased cancer risks develop slowly and the health change may take some time after a decrease in pollution levels. Secondly, it is difficult to control for confounders in a longitudinal perspective. Various societal processes like economic transition, population out-migration and demographic shifts may overlap with plant closure and it will become impossible to separate plant closure's impact on health and economic indicators [4]. The evaluation of even a quasi-experimental event like plant closure becomes more complicated over longer periods since changes in the composition of the population obscure the effect of pollution reduction on health outcomes. Thirdly, availability of relevant data is uneven. Air pollution levels and hospital admissions are easy to get but there are no data on finances and labor market dynamics. Fourthly, spillover effects may arise in neighboring towns where data is not available [6, 10].

Natural experiments when the shutdown occurs as an unanticipated event offer one possible way of strengthening the causal inference. However, natural experiments happen quite rarely. Each of them has distinct characteristics which makes generalisation impossible. For this reason, comparative case studies become a relevant tool: it does not produce any statistical estimates, but it uncovers the mechanisms which connect closure, pollution reduction and policy response to community outcomes.

3. State clean energy policy: the Virginia Clean Energy Act

One of the key instruments of the energy transition at the state level is the state legislation. Virginia Clean Energy Act (VCEA) offers an example of the contradiction between legislative mandate and practical capacity to implement decarbonisation policies in the communities which are affected by the transition. This law was enacted with the aim to set mandatory climate requirements for

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Virginia's electric utilities and establish long-term decarbonisation targets and schedule of carbon emissions reduction from the power sector. On paper, the legislative mandate provides regulatory impetus for coal plant shutdown and renewable energy generation.

The graph presented in Figure 2 below is an example of a long-run trend of the annual average amount of fine particulate matter (PM2.5) in three localities of Virginia (Norfolk, Hampton and Chesterfield) from 2010 to 2026. In all three localities, there is a general trend of a decrease in the concentration of pollution during the stated period of time, reflecting the larger decarbonization policy in Virginia, represented by the Virginia Clean Energy Act, while short-run yearly fluctuations persist.

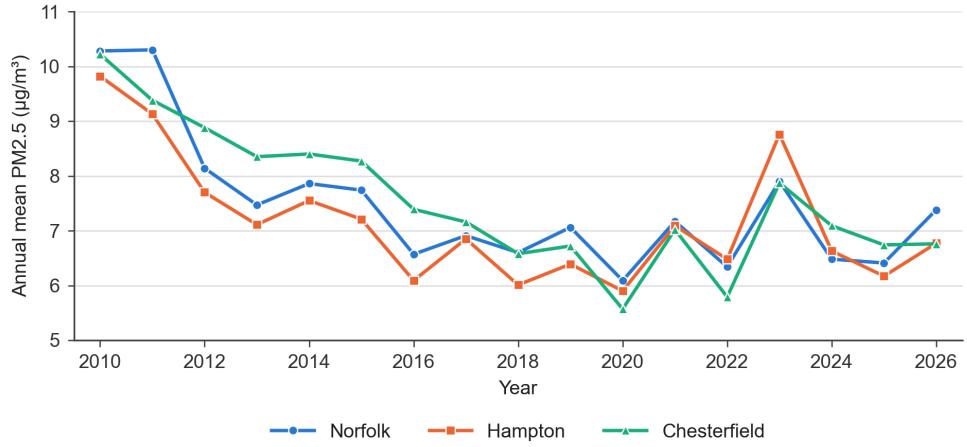

Figure 2. Annual mean PM2.5 concentrations (µg/m³) across Norfolk, Hampton and Chesterfield, 2010–2026

Nevertheless, legislative mandates in themselves cannot deal with local transition risks. The Virginia Clean Energy Act requires utilities to reduce their carbon footprint, but it does not mean that there would be resources set aside for the transition to be compensated. There is a kind of legislative vacuum created by mandate, which means that utilities have the obligation to decarbonize and therefore shut down and that the funding required for the transition is elsewhere [7].

It becomes evident that the VCEA can offer useful background for understanding the two case studies in Section 4. Comparison of the communities with and without transition funds will show that the transition policy outcome depends on decarbonisation mandate as well as on accompanying fiscal measures and multi-stakeholder engagement. Otherwise, the health gain from the pollution reduction will be accompanied by unnecessary economic crisis.

4. Cross-case synthesis

4.1. Case selection

The selection of Huntley Coal-Generating Station and Shenango Coke Works for comparison is based on several important factors. Both plants stopped functioning in 2016 and operated in nearby regions, suggesting that those two plant closures came under similar economic conditions. This provides the basis for the comparison of these two plant closures. However, there are differences in the causes of the closures and equity-transition policy implementation. The shutdown of Shenango was caused by overcapacity in the global market of steel products, not by any environmental regulations in the USA. Thus, the closure of Shenango offers a standard quasi-natural experiment to

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examine the impact of removing pollutants from air on public health in that it is not driven by local factors. Huntley stopped functioning after a significant decline in production that stemmed from regulation and decrease in natural gas prices, which are alternative sources to coal for generating power. Besides, these two sites offer complementary empirical information: Huntley has plenty of socioeconomic and financial data, but no measures of quantified health outcomes; meanwhile, Shenango has records of health outcomes, but no significant socioeconomic data. This will allow the discussion of both health benefits and socioeconomic losses of closing coal facilities.

Some of the key comparative dimensions in the two cases are presented in Table 1.

Table 1. Key comparative dimensions of the Huntley and Shenango cases (adapted from [3, 11])

Dimension	Huntley (NY, closed 2016)	Shenango Coke Works (PA, closed 2016)
Primary shutdown driver	Market competition + stricter environmental regulation	Global steel-market overcapacity (non-domestic-policy shock)
Available policy-mitigation support	USD 69 M state transition fund; multi-stakeholder Huntley Alliance	No dedicated local transition-programme
Socio-economic outcomes	Workers re-employed / retired; tax loss buffered by state funds; residual risks: industrial-water supply, polluted brown-field	Limited public data for fiscal / indirect-labor-market impacts
Public-health evidence	No quantified local-health metrics	Measurable health gains: 40% drop in pediatric-asthma emergency room admissions, reduced respiratory hospital visits
Strength & limitation	Comprehensive socioeconomic-fiscal records; absence of quantified-health results	Rare pollution-health natural-experiment; missing systematic socioeconomic data

4.2. The Huntley case

Huntley coal station in Tonawanda, New York, was shut down in 2016. Its closure was caused by tightening of the environmental regulations and competition from gas and renewable energy sources. Recognizing the risk of abrupt closure, New York has allocated special USD 69 million transition fund and created the Huntley Alliance which consisted of the government, labor unions, utility operators and community representatives [11].

This package of measures helped to buffer the consequences of the closure. Most of the workers received alternative jobs or accepted retirement packages. The loss of municipal tax base was mitigated, but the liability remained. After the closure, the site has turned into brownfield.

The Huntley case shows the potential model of just transition, which is nevertheless resource-intensive. Pre-existing state fiscal capacity was the crucial enabling factor for the success of this project. It restricts replicability; the states with limited budget are unable to provide the same funds

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for transition planning. Despite the fact that the socio-economic impact was mitigated, the available evidence does not contain any quantified local health improvement after the closure.

4.3. The Shenango case

Shenango Coke Works was closed in 2016 amid steel overproduction crisis in the global market, not mainly owing to US domestic environmental policy. It becomes a natural experiment: this facility has produced coke for steel making and emitted particulate air pollution affecting local residents. Unlike Huntley, there was no state-level or local transition program created prior to the closure [3].

The most important empirical finding of the Shenango case is the measurable public health improvement. Several papers have shown that there was a sharp decrease of about 40% of pediatric asthma emergency admissions in Shenango. This demonstrates that the pollution reduction provided welfare benefits for local residents. However, the evidence on socio-economic impact of the closure is less complete. Job losses were documented, but there is no information on municipal tax revenue changes and labor market outcomes.

The Shenango case proves the core trade-off: pollution removal results in rapid health improvement without any transition policy. However, the community suffers from job losses without any formal compensations. The Shenango case also demonstrates that a natural experiment may make it possible to estimate the health effect, but it lacks information on socio-economic impact.

4.4. Complementary lessons

Both cases provide complementary lessons. Huntley shows that state-level transition funds and multi-stakeholder dialogue can cushion fiscal and labor market impact of the closure, but they depend on state budget and cannot be applied everywhere. The Shenango case shows that pollution removal brings measurable health benefits, but in the absence of any transition program, the community has to deal with job losses. Thus, both closure and policy lead to positive and negative local consequences.

5. Discussion

5.1. Theoretical implications: revisiting externality theory for energy transitions

The comparative evidence modifies the traditional negative-externality model of coal closure. Traditionally, the theory focuses on the static pollution externality of the plant operation: air pollution brings uncompensated health damage to the residents, and the regulation that reduces pollution leads to increase in social welfare [7, 8]. The empirical evidence provided by this paper, especially Shenango case, confirms this prediction.

However, the cases also provide information about the new kind of externalities that emerges during the transition process. Closure of the facility generates new local costs: eroded tax base, vulnerable public infrastructure and labor market disruption. These are the distributive externalities. While total welfare increases, the affected communities may suffer from the net loss unless the compensation scheme is implemented in the policy. In this case, efficient decarbonisation is not necessarily equitable [2]. Theory of just transition could be viewed as a need to address this distributional inefficiency.

Traditional Pigouvian pricing remains an elegant theoretical solution, but its application faces political and fiscal constraints. According to the evidence provided by this paper, hybrid models of

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policy are more realistic: emissions regulations coupled with targeted transition funding and brownfield remediation budget along with multi-stakeholder governance [7].

5.2. Empirical implications: limits of causal inference

The two cases demonstrate difficulties of clean causal inference in the framework of environmental policy evaluation. Shenango case benefits from the quasi-experimental design because the closure has happened due to global market shocks and not due to domestic environmental regulations. Therefore, it is easier to separate the health effects of pollution abatement from other policies [3]. Nevertheless, it is still impossible to rule out completely the influence of other health trends in the region. Beyond short-run hospital admissions such as pediatric asthma, many pollution related chronic health conditions take years or decades to manifest, further complicating long-run causal attribution.

In contrast to Shenango, Huntley provides abundant information on the socio-economic and fiscal impact of the closure, but identification for health impacts is weak. The closure was triggered by overlapping regulation and market factors, which makes it difficult to separate the effect of air pollution reduction from other concurrent regional changes [11].

Thus, the general empirical lesson is that single outcome measure (e.g. asthma admission rate or tax revenue) captures only part of community impact. The researchers are faced with a trade-off: the setting with cleaner causal identification lacks socio-economic administrative data, while the case with policy often contains confounding [4]. Comparative case analysis may help with the triangulation of the evidence, but it cannot substitute large-scale quantitative analysis.

5.3. Policy implications

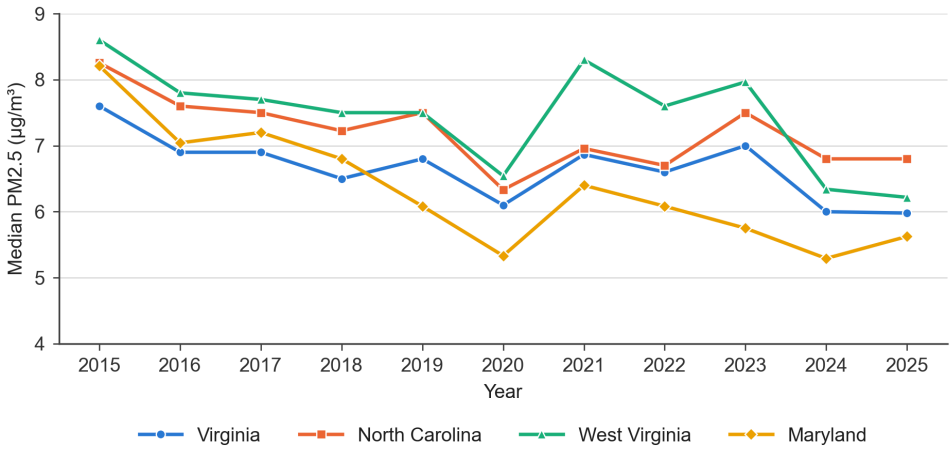

Figure 3. Median PM2.5 concentrations (μg/m³) across four Mid-Atlantic states, 2015–2025

Climate policy of the state, such as Virginia Clean Energy Act, sets emission goals; however, legislative goals are not enough for protection of local communities from negative impacts of transition. As seen in Figures 2 and 3, state-level climate policy, like VCEA, can produce gradual air quality benefits; however, these benefits are not automatically going to help in overcoming the economic problems of local communities. The policy needs to consider two separate levels: regulations for pollution reduction and financial mechanisms for managing local costs of transition. Huntley example demonstrates that financing of transition and inclusive multi-stakeholder planning

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can be helpful [11]; at the same time, this case indicates the main limitation: the model of Huntley is budget-driven and cannot be replicated in other states.

Therefore, the separation of decarbonisation goal and transition funding is needed. Before the closure of the facility, the government should calculate municipal budget exposure, disruption risks in labor markets and site liabilities. Transition fund should focus on communities which lack other industries opportunities, not only on communities which have enough state budgetary opportunities.

6. Conclusion

This paper analyses local socioeconomic and public-health consequences of U.S. coal-related facility shutdowns, based on the negative-externality environmental-economics theory and the comparative case studies of Huntley Coal-Generating Station and Shenango Coke Works.

Empirical evidence confirms that retirement of high-polluting fossil fuel infrastructures is associated with measurable public health benefits in the form of decreased asthma emergency admissions, most clearly seen in the Shenango natural-experiment case. At the same time, the Huntley case demonstrates that coal-plant shutdowns bring about local costs including erosion of municipal tax base, industrial infrastructure vulnerability and costly site remediation. These local impacts can be alleviated by state-level transition funds and inclusive multi-stakeholder planning, but such measures depend on state fiscal capacity and are not easily replicable elsewhere.

In terms of empirical research, the study confirms the difficulty of causal inference in environmental policy evaluation. Natural-experiment shutdown events are rare and often capture only some specific outcomes; evidence is often rich on health metrics and poor on local fiscal and labor-market impacts, or vice versa. Comparative case analysis offers a useful approach to the evidence triangulation, but it is unable to provide statistical estimates of population-wide effects.

This study has some limitations. It uses only two US-based case studies and does not consider poor rural coal-dependent communities; generalizability to other regions and countries remains unknown. Also, the study uses secondary published reports and not primary data collected by the author.

In terms of future research, more natural experiments around shutting down plants will contribute to building a better database for understanding the effects of pollution reduction on communities. Another possibility would be to examine state-level transitions in different fiscally capable states in order to understand the role of budgets in achieving just transitions. From a policy standpoint, the key lesson here is straightforward: the design of the policy to reduce emissions and protect the community needs to go hand-in-hand.

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