Carbon Taxation: Retraining, Retrofitting, and Innovating to Support China's Equitable Energy Transition

Thesis Statement

To mitigate the harmful effects of coal and promote a just energy transition, we propose a pilot provincial carbon tax on the Shanxi coal industry. The tax revenue will be utilized to retrain at-risk workers, increase innovation, retrofit coal facilities into geothermal plants, redistribute income, and weather-proof the transmission grid.

Background & Analysis

Anthropogenic climate change is the defining issue of our generation. As China's economy has rapidly grown over the past 15 years (University of North Texas Libraries Government Documents Department, 2019), so has their emissions of noxious gases including CO_2, SO_2, and NO_x. Despite their advancements in solar and other forms of renewable energy, China remains the world's largest air polluter (Fernandez, 2020). China's government has declared this rise in emissions unsustainable and is fighting to achieve net carbon neutrality by 2060, with President Xi Jinping calling to 'make skies blue again' (Varro & Fengguan, 2020). Yet China has many regions whose economies are solely reliant on fossil fuel production, raising concern over the imminent disenfranchisement of their poorest and most vulnerable workers.

There are multiple key stakeholders in these issues. The long-term welfare of both the national and global populations depends upon China curbing its carbon emissions in the fight against climate change. On a national level, soaring levels of asthma, lung cancer, and other respiratory ailments are being observed in areas of high pollution (Millman, Tang & Perera, 2008). However, while a swift green energy transition is essential, it must consider the economic viability of the energy companies and the communities they are found in. To position itself at the vanguard of the renewable energy movement, the Chinese government is incentivized to support legislation to reduce carbon emissions while protecting its citizens.

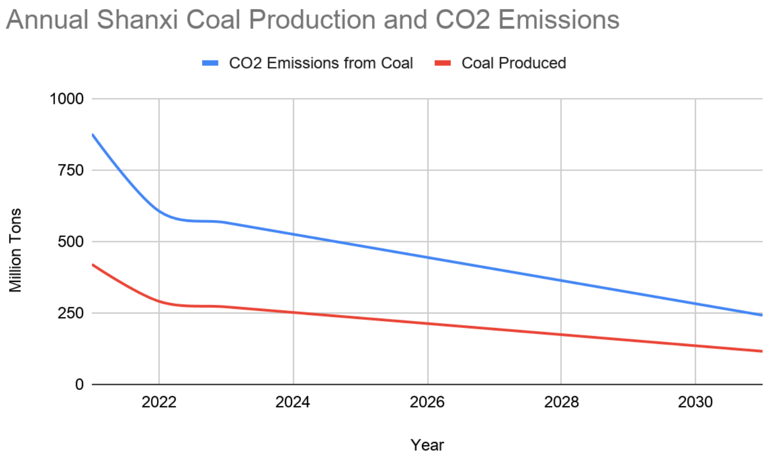
Without decisive policy measures, China's sustained CO_2 emissions through coal production will set the world on a collision course towards even greater global temperature increases and the associated negative externalities. Simultaneously, if legislation does not account for the workers that may be displaced by a green energy transition, it could disenfranchise hundreds of thousands of workers and have grave economic effects.

The Policy Idea

We propose a national Carbon Tax, with a provincial pilot program in Shanxi. The tax starts at a base rate of ¥129.6/ton of CO_2 and increases annually by ¥16.00/ton. 20% of the revenue generated would be earmarked for weatherproofing, modernizing, and extending the grid; 25% would be directed towards easing the transitioning process from fossil fuels by retrofitting coal mines and power plants into geothermal power plants. To avoid displacing at-risk workers, we will direct 10% of the first year carbon tax revenue towards educating and retraining coal workers, and the funds would be allocated for Geothermal Innovation in future years. The remaining 45% will be allocated equally amongst community members who are in the bottom income quartile based on data from the National Bureau of Statistics.

Policy Analysis

For carbon taxation to prove effective in furthering environmental advancements whilst also sustaining a healthy economy, it must involve wealth redistribution. The taxation of carbon at a rate of ¥129.6/ton of CO_2, increasing annually by ¥19.4/ton, would fund a multi-pronged approach to protect both the economy and the environment. These values allow for a reduction in coal combustion CO_2 emissions of over 70% by 2030, which promotes China's 2060 carbon neutrality goals. It would also prevent severe economic disruption through excessive fuel price hikes (only about ¥5.83 per gallon) (Kaufman et al., 2019).

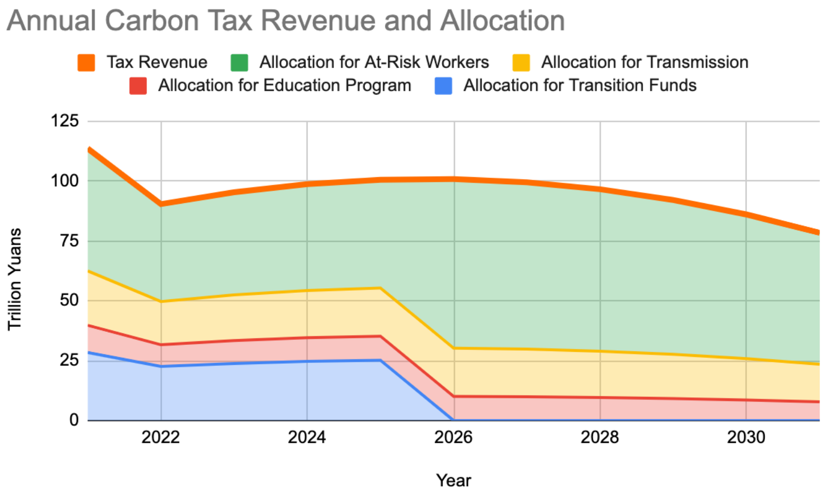


The above graph depicts Shanxi's coal production over time under the carbon tax, as well as the CO_2 emissions resulting from the coal produced.

Energy-producing commercial entities will be taxed for CO_2 emissions. 20% of funds will be allocated as transition funds, to retrofit coal plants and convert them into geothermal plants. Geothermal energy was chosen for its geographic suitability along with similar worker skills (EGEC Geothermal, n.d.), minimizing economic disruptions and layoffs. Geothermal plant retrofits will cost ¥9206[1] per kW of capacity (U.S. Energy Information Administration, 2020), and with a total fossil fuel power plant production capacity of 66.82 GW in Shanxi (Xinhau, 2019), it will cost ¥61.5 billion to completely replace fossil fuel power generation in Shanxi.

[1] Please see Appendix 2 for detailed calculations.

This amount will be staggered over five years and in segments that will complete different areas of retrofitting to prevent supply-side issues. Taking into account a 3.0% growth of energy consumption per year (Shanxi Provincial Bureau of Statistics & Survey Office of the National Bureau of Statistics in Shanxi, 2018), we would need a further ¥488 billion, taking the total to ¥550 billion. Based on our taxation plan, there will be ¥128.8 billion funding for the tax program (without accounting for private investments).



The above graph depicts the revenue generated by the carbon taxation, as well as the areas in which the tax funds are allocated over time.

The carbon tax will protect at-risk workers by integrating them into the province's geothermal transition, through a retraining program accounting for 10% of carbon tax revenue in the first year. Training materials will be prepared at a national level by a dedicated task force, with trained educators dispersed throughout the province to retrain all at-risk energy workers by the year's end. This will cost ¥2.8 billion,[2] well within the ¥11.6 billion allocations. In the next 9 years, ¥90.0 billion will be allocated for renewable energy innovation to allow further improvements in geothermal efficiency and lower future retrofitting costs, which will be allocated as grants to public universities and research centers.

The carbon tax also allocates 20% per year to pursue grid transmission improvements. Grid congestion in China is increasing, resulting in multiple blackouts and, recently, the need to regulate power usage (Chen, 2020). Simultaneously, China wasted 7% of wind energy produced in 2018 alone due to its lack of transmission capabilities (O'Meara, 2020). As energy demand in China increases and more grid lines are built in high-risk areas, China must invest in more transmission lines and weather-proof its existing transmission. China plans to spend close to ¥6 trillion on transmission (Reuters Staff, 2020) within the next five years, and contribute ¥103 billion to improve transmission capabilities.

[2] Please see Appendix 3 for detailed calculations.

One potential weakness to our proposition is the likelihood that the increased revenue generated by the carbon tax will cause inflation, raising the price of goods and de-incentivizing consumer spending. The carbon tax addresses this by distributing the remaining carbon tax revenue to the province's lowest income quartile (see appendix for relevant calculations). This will provide ¥10,887 per capita, roughly 85% of the province average of ¥12,819 for rural regions, where most coal mines are located (Shanxi Provincial Bureau of Statistics & Survey Office of the National Bureau of Statistics in Shanxi, 2018).

Next Steps and Action Plan

Through engaging with the Chinese government on a local and national level, along with industry leaders and international agencies, we will ensure that this policy aligns with China’s legislative priorities and is passed into law.

Government: We will propose our policy memo to the Ministry of Ecology & Environment, and assist them in drafting an official bill proposal. Once the bill has been formed, we will work with the ministry leader to submit the bill to the National People’s Congress (NPC) and work with the Legislative Affairs Office (LAO) to ensure its passage and approval by the State Council (The US-China Business Council, 2009). We will facilitate meetings between the national and provincial governments to ensure the bill balances with their different priorities (the national government’s focus on emissions reduction and the provincial fear of job loss and economic devastation) and would be enacted without delay. We will also work with the Party Secretary and the Governor of Shanxi to ensure a common understanding is reached and that the policy can be enacted swiftly and smoothly.

Academia: We will build partnerships with universities and innovation centers, ensuring procurement of the industrial and intellectual capacity to retrofit power plants and retrain workers when the policy passes. We will approach the Chinese Academy of Sciences to determine which research groups align with our policies and work with them to develop a formal screening process for innovation grant requests.

Industry Leaders: We will work with Industry Leaders to ensure smooth facilitation of the policy. We will also work to understand their concerns, suggestions, and feedback, to allow better implementation of the policies, have a better understanding of the ground-level implications of such policy, and prevent alienation of certain worker groups.

International Agencies: We will approach organizations such as the IPCC, updating them on our proposed legislation and encouraging them to open dialogue with China to recognize their efforts in reducing carbon emissions.

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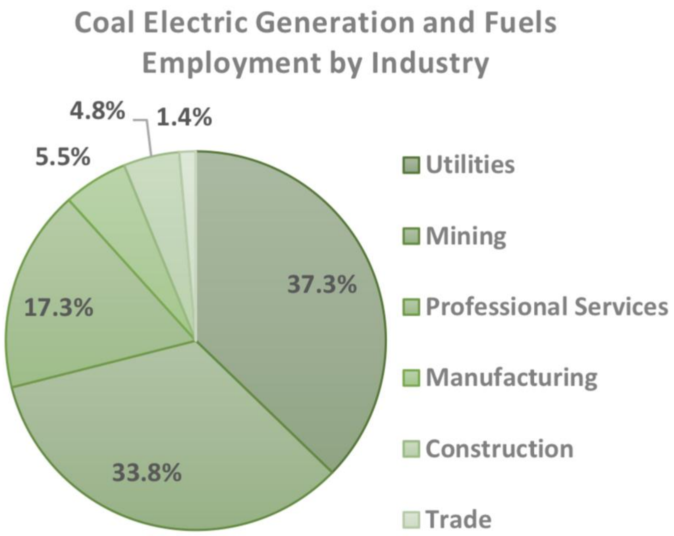
Appendix

Appendix 1: Coal Industry Employment Breakdown[3]



This figure shows the breakdown of employment in the coal industry in the US.

Appendix 2: Retrofitting Costs

Initial Capital Cost: US$ 126,055,000

Existing Power Plant Savings:
- Land Costs: US$ 2,000,000
- Electrical Interconnection: US$ 1,200,000
- Mechanical - Steam Turbine: US$ 18,750,000
- Mechanical - Balance of Plant: US$ 19,663,000
- Owner Services: US$ 12,150,000
- EPC Fee: US$1,229,000

Total Cost of Retrofit: 126,055,000 - (2,000,000 + 1,200,000 + 18,750,000 + 19,663,000 + 12,163,000 + 1,322,000) = US$70,957,000 ≈ ¥460 million → for 50 MW
Per kWh cost: ¥9206

Additional Production Capacity by 2030: 86.87 x $(1.03)^{10}$ - 86.87 = 29.8 GW
Costs for Added Capacity: 2521 x 29800000 = US$75.3 billion ≈ ¥488 billion

[3] (U.S. Department of Energy, 2017)

Case 15 EIA – Capital Cost Estimates – 2019 $s			
Configuration		**Geothermal** 50 MW	
Plant Configuration		Binary Cycle	
	Units		
Plant Characteristics			
Net Plant Capacity	MW	50	
Capital Cost Assumptions			
EPC Contracting Fee	% of Direct & Indirect Costs	15%	
Project Contingency	% of Project Costs	8%	
Owner's Services	% of Project Costs	12%	
Estimated Land Requirement (acres)	$	200	
Estimated Land Cost ($/acre)	$	10,000	
Electric Interconnection Costs			
Transmission Line Cost	$/mile	1,200,000	
Miles	miles	1.00	
Substation Expansion	$	0	
Typical Project Timelines			
Development, Permitting, Engineering	months	24	
Plant Construction Time	months	36	
Total Lead Time Before COD	months	60	
Operating Life	years	40	
Cost Components (Note 1)		**Breakout**	**Total**
Civil/Structural/Architectural Subtotal	$		8,463,000
Mechanical – Steam Turbine	$	18,750,000	
Mechanical – Production / Injection System	$	21,644,000	
Mechanical – Balance of Plant	$	19,663,000	
Mechanical Subtotal	$		60,057,000
Electrical – BOP and I&C	$	5,475,000	
Electrical – Substation and Switchyard	$	4,302,000	
Electrical Subtotal	$		9,777,000
Project Indirects	$		9,838,000
EPC Total Before Fee	$		88,135,000
EPC Fee	$		13,220,000
EPC Subtotal	$		101,355,000
Owner's Cost Components (Note 2)			
Owner's Services	$		12,163,000
Land	$		2,000,000
Electrical Interconnection	$		1,200,000
Owner's Cost Subtotal	$		15,363,000
Project Contingency	$		9,337,000
Total Capital Cost	$		126,055,000
	$/kW net		2,521

***Capital Cost Estimate of a 50 MW Geothermal Power Plant* (U.S. Energy Information Administration, 2020)**

Appendix 3: Worker Retraining Calculations:

Estimated Cost of Trainers:

$2400\ trainers\ (¥14,700\ *\ 12\ +\ ¥13,000)\ =\ ¥426,480,000$

Estimated Cost of Program Developers (1 year):

$30\ program\ developers\ *\ ¥162,000\ /program\ developer\ =\ ¥\ 4,860,000$

Estimated Cost of Paying Workers during Training:

$800,000\ workers\ *\ ¥18.5/hour\ *\ 40\ hours/week\ *\ 4\ weeks\ =\ ¥\ 2,368,000,000$

Estimated Total Cost of Retraining:

$¥426,480,000\ +\ ¥\ 4,860,000\ +\ 2,368,000,000\ =\ ¥2,799,340,000$

Estimated Cost of Retraining Calculation Assumptions:

These calculations are based upon several key assumptions. Based on our estimate that there are 800,000 manual coal laborers in Shanxi,[4] and the fact that there are 954 coal

[4] Based on the fact that there were nearly 1 million workers in the Shanxi coal industry in 2016 (Bridle *et al.*, 2017), and Appendix 1 (U.S. Department of Energy, 2017), which we used to estimate that about 80% of coal industry workers are manual laborers who would be at risk of disenfranchisement due to this transition.

mines in the region,[5] we concluded that there was an average of 850 workers per factory that needed retraining. Our assumption that there would be 1 trainer for every 30 workers, coupled with our plan to retrain all workers in one year, led us to conclude that we would have 80 factories in re-training every month that each required 30 teachers. Therefore, we estimate that 2400 (80*30) teachers are needed.

Regarding the payment of the workers, the ¥18.5/hour figure represents the highest minimum wage of the province.[6] It is assumed that workers will work for 40-hours per week that is split between their standard employment duties and their geothermal training. Based on existing geothermal qualification programs,[7] it is expected that workers should be able to complete their training within 1 month of concentrated study.

To calculate the trainer's pay, we identified the average teaching pay in China[8], with an additional 2-way travel stipend[9] and daily living stipend[10], respectively based upon travel and living costs in the region. Additionally, the curriculum developer's pay is based on the mean salary of curriculum developers in China.[11]

Appendix 4: Annual Carbon Tax Figures

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Tax Rate (Yuans/ ton)	129.6	149.04	168.48	187.92	207.36	226.8	246.24	265.68	285.12	304.56	324
Coal Produced (Tons)	420000000	290640000	271236000	251832000	232428000	213024000	193620000	174216000	154812000	135408000	116004000
CO_2 Emitted from Coal (Tons)	876120000	606275040	565798296	525321552	484844808	444368064	403891320	363414576	322937832	282461088	241984344
Carbon Tax Revenue (Yuans)	113545152000	90359231962	95325696910	98718426052	100537419387	100782676915	99454198637	96551984552	92076034660	86026348961	78402927456

Appendix 5: Both graphs in the main body were generated by a member of our team.

[5] (Reuters Staff, 2020)
[6] (Textor, 2020)
[7] (Heat Spring, n.d.)
[8] (Mitchell, 2019)
[9] (Budget Your Trip, n.d.)
[10] (Numbeo, n.d.)
[11] (PayScale, 2018)