PEOPLE OF ASIA FOR CLIMATE SOLUTIONS

People of Asia for Climate Solutions (PACS) is a climate advocacy group with operations in the Philippines and China. PACS is dedicated to championing "people-centered climate solutions". Through close collaboration with climate and energy experts and non-governmental organizations in both China and Southeast Asian countries, PACS is actively working on three specific fronts: A Coal-Free Future, Belt and Road Initiative Direction to Green Energy (BRIDGE) and Climate Actions. Through its strategic advocacy and collaborative endeavors, PACS seeks to drive meaningful change and foster a more resilient, environmentally conscious world for generations to come.

SHANXI COSHARE INNOVATION INSTITUTE OF ENERGY & ENVIRONMENT

Shanxi Coshare Innovation Institute of Energy & Environment (hereinafter referred to as Coshare) was registered with the Shanxi Department of Civil Affairs in January 2017. Coshare is a nonprofit research organization and collaborative innovation platform dedicated to promoting regional sustainable development, and Coshare serves as an observer organization to the United Nations Framework Convention on Climate Change. Since its establishment, Coshare has conducted research in areas including low carbon and clean energy, waste resource utilization and harmless treatment, ecological environment protection and restoration, green industry innovation, and environmental social governance. From the perspectives of strategic research, policy support, technical recommendations, social advocacy, and capacity building, Coshare provides green low-carbon transition solutions for governments, enterprises, and the public.

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Energy Shift Institute (ESI) is a nonprofit energy finance think tank that aims to provide context, clarity, and credibility for Asia's energy transition pathways. Headquartered in Australia, ESI offers pioneering thought leadership that focuses on finance and energy matters in Southeast Asia, along with analyses related to investment dynamics involving East Asian markets. Its work heavily relies on an evidence base, and is built on reasoned, balanced, and market-relevant knowledge that adeptly addresses the intricate complexities of Asian markets. ESI aims to help position Asia for its future economic leadership by facilitating a more aggressive energy transition.

TRANSITION: THE ONLY OPTION

A 2ND EXPLORATION FOR A ROADMAP TOWARDS A COAL-FREE FUTURE IN SHANXI, EAST KALIMANTAN, SOUTH SUMATRA

2024.7

山西派可思绿色立化中心
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Shanxi Coshare Innovation Institute of Energy & Environment

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Special thanks go to the Shanxi Carbon-Peak-Carbon-Neutral Energy Revolution Research Institute (CCERR) and Institute for Essential Services Reform (IESR) for their valuable feedback on this report.

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Rational Optimism for a Coal-Free Future

(Wang, Xiaojun)

One of the most well-known names from Shanxi Province in recent years is Liu Cixin, whose novels such as the Three Body Problems and the Wandering Earth, have kept readers around the world on the edge of their seats. The future for humanity and our planet, in his books, is so far yet so close.

The universe is dark, distant, dangerous and daunting, just like the coal mines in his hometown Yangquan. Set in the future, Liu's books are asking us to work together for humanity's survival while reflecting on how crises have been brewed by our disrespectful treatment to the planet. Set in harsh present reality, the worsening climate change crisis is no less than a survival challenge that requires immediate united actions, such as to curb coal mining and burning.

Outside Yangquan, most other parts of Shanxi also have substantial coal reserves. Shanxi is the world's largest coal producer, with an annual output of over 1 billion tonnes each year in the last two decades, reaching almost 1.4 billion in 2023. Up to 70% of all Shanxi coal is transported to other provinces in China to generate electricity, provide heating or power heavy industries.

In 2023, China's coal consumption reached 3.7 billion tonnes, and 216 million came from Indonesia. That means every 100 tonnes of coal leaving Indonesia, 40 went to China.

Indonesia's two largest coal producers are East Kalimantan and South Sumatra, with a combined output of 400 million tonnes each year. Just like Shanxi, most of their coal is transported or exported to support domestic consumption or overseas markets, especially in China and India.

In 2023, the global coal consumption reached an all-time high, mostly due to surges in China, India and Indonesia. While contributing to local economies in Shanxi, East Kalimantan, and South Sumatra, as well as their respective countries' development, coal has locked them into a coal addiction. Even worse, coal mining and burning are leaving tremendous irreversible impacts on local environment and public health and vomiting greenhouse gases such as carbon dioxide and methane, further destabilizing the planet's climate.

The coal addiction is a coal curse.

This is a curse that global society is trying to break free from, when global mean temperature is continuously making new records and extreme weather events are frequently making headlines. At the COP28 in Dubai in late 2023, the world agreed to "transition away from fossil fuels", striking the clearest and loudest farewell bells to fossil fuels.

A fossil fuel free future is tangible and within reach.

China initiated its energy transition as early as 2005 with the launch of the Renewable Energy Law, and further developed and released, in 2014, the New Energy Security Strategy that aimed to build "an energy system that is clean, low-carbon, safe and efficient, through revolutions in energy consumption, energy supply, energy technology, and energy system, as well strengthened international cooperation in all aspects". In 2020, this position was further solidified with the global commitment of "Dual Carbon Targets", i.e. to reach carbon emission peak by 2030 and carbon neutrality by 2060. The direction is set, clear and solid.

Coal burning, as the sole largest source of carbon dioxide emission, will be the first of all fossil fuels to bid its farewell. This leaves major coal producers and coal dependants, such as Shanxi, East Kalimantan and South Sumatra, no more than two options: early preparation for a coal-free future, or waiting to sink with coal. The latter is apparently not a wise or responsible option.

Shanxi, as China's "Pioneer on Energy Revolution", started its long march over a decade ago.

China set up a Pilot Zone of Comprehensive Reformation for Resource-Heavy Regions in Shanxi in 2010. Numerous policies and action plans have been produced, covering renewable energy targets, reformation among the coal industry and coal user industries, and low-carbon urbanization and transportation. During China's

13th Five Year Plan Period (2016 to 2020), Shanxi closed down over 100 coal mines that had a combined capacity of 130 million tonnes, and repositioned 118,000 coal miners and workers. During the 14th Five Year Plan Period (2021 to 2025), Shanxi has set a target for renewable energy to contribute half of the total installed capacity by 2025. All these policies and targets have tripled down into real change. In 2023, Shanxi's renewable energy installed capacity reached 39.9%, and it sold 2.3 billion KWh of electricity to other regions and cities, including Beijing and Shanghai.

This is a tiny step Shanxi has taken, compared to the long complicated and challenging march lying ahead of it in the coming decades. The province's energy, economy, and society will all go through a painful yet necessary transformation and transition. The same goes for all current coal suppliers for China. By planning to "cut its coal consumption during the 15th Five Year Plan Period (2026 to 2030)", China has sent a strong signal to coal producers, Shanxi, East Kalimantan, and South Sumatra all included, that China's coal market is about to shrink soon. They must start immediately to experiment and explore diverse and innovative growth paths without coal.

The only certainty down these new paths is uncertainty, just like the universe and humanity future in Liu Cixin's novels. In his hometown Yangquan, in 2023, coal production, transportation, and income all started to decline, with over 7,000 people unemployed. There is likely a much longer line in the coming years, including but not limited to the 900,000 current coal industry workers in Shanxi.

Shanxi has a lot, hard lessons and good lessons, to offer to other coal producers, such as East Kalimantan and South Sumatra. Shanxi also has plenty to learn from the Indonesian coal producers, as they all face similar challenges, ranging from lack of coal policy making power, lack of new economic growth opportunities, lack of upskilling programmes, and lack of financial support.

They cannot complete their coal-free expeditions by themselves. Clearer guidance and stronger support from their central governments and other provinces are needed. More importantly, global support is needed. One gram of coal produced in Shanxi, East Kalimantan, or South Sumatra, could ultimately become the last straw for the planet's climate.

The expeditions have started, full of challenges and questions. At least, they can explore and seek answers and solutions in solidarity, which is exactly what we, as non-governmental organizations and think tanks, would like to bring about through these subnational dialogues between the coal producer provinces. The learning and sharing among them is crucial, and the mutual encouragement is essential by giving them the strength to move forward, knowing they are not alone.

In an interview about humanity's future, Liu Cixin called himself a "rational optimist." He said, "I believe human civilization has a bright future, (and) this positive future will only be reached via a long and winding historical course." The long and winding historical course to rescue the planet's climate and humanity's chance of survival from a fossil fuel addiction epidemic has already started, and being rationally optimistic is the only attitude we are left to have in this fight.

" The phaseout of fossil fuels is essential and inevitable. No amount of spin or scare tactics will change that. Let's hope it doesn't come too late."

António Guterres
United Nations Secretary-General

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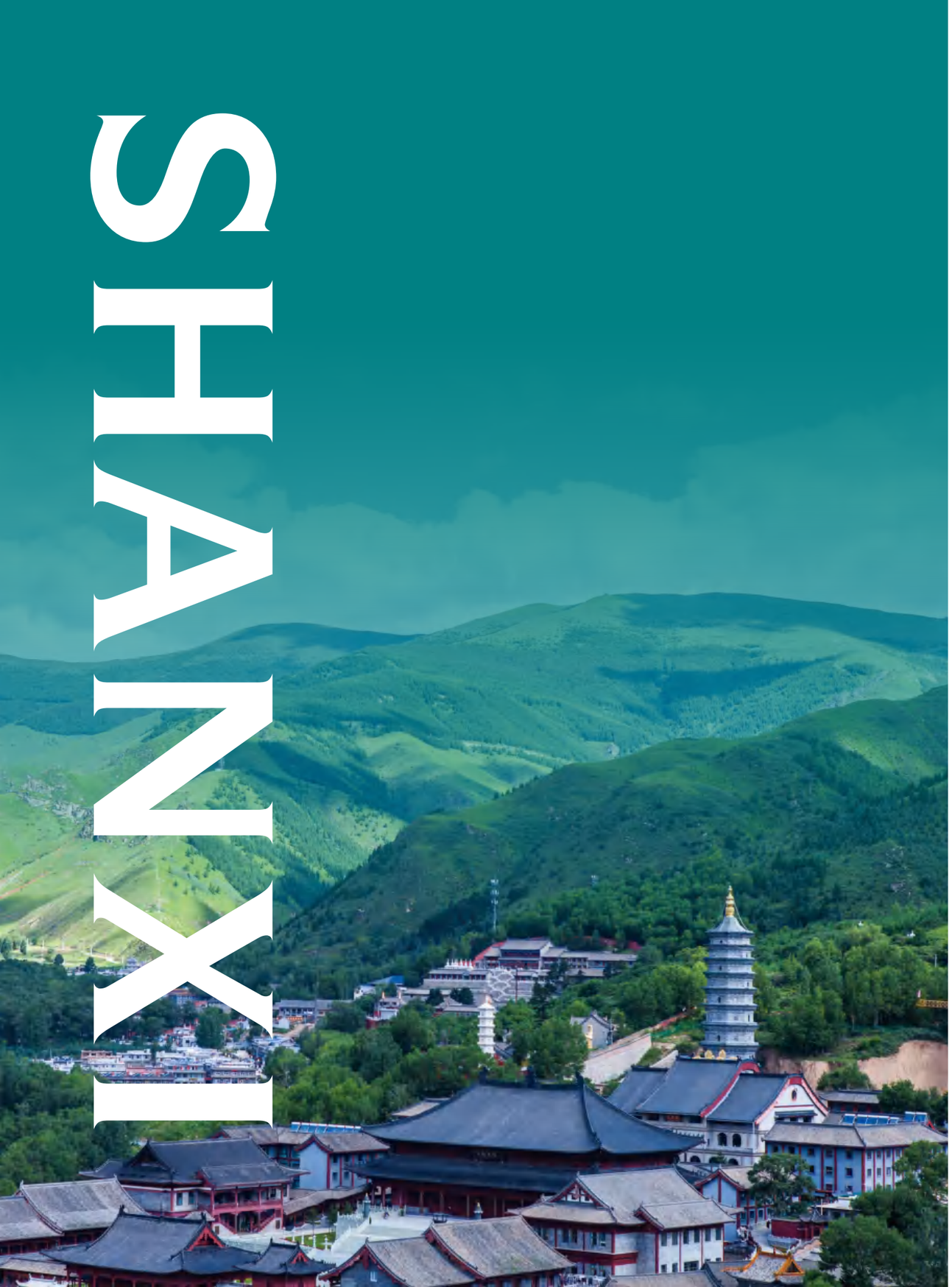


TRANSITION AWAY FROM COAL: THE CASE OF SHANXI

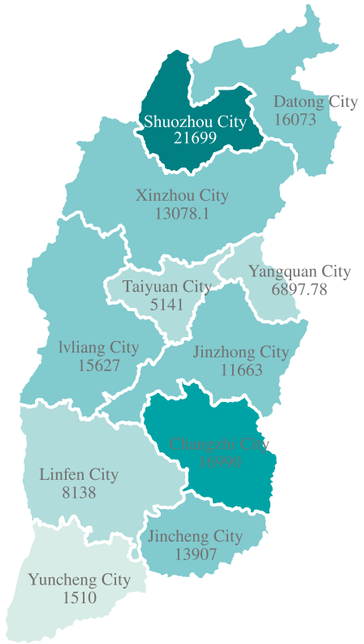
01 SHANXI PROVINCE PROFILE

Figure 1-1 Location of Shanxi Province

Image Review No.: GS (2024) No.4308
Approved by the Ministry of Natural Resources

Shanxi Province, located in North China, is undertaking a national pilot reform program for economic and energy transition in resource-rich regions. Lying on the Loess Plateau in the middle reaches of the Yellow River, Shanxi is adjacent to Hebei Province, Shaanxi Province, Henan Province, and Inner Mongolia Autonomous Region, covering a total area of 156,700 square kilometers. The province is divided into 11 prefecture-level cities, namely Taiyuan, Datong, Shuozhou, Xinzhou, Yangquan, lvliang, Jinzhong, Changzhi, Jincheng, Linfen and Yuncheng. The 11 prefecture-level cities have jurisdiction over a total of 117 county-level administrative units, including 26 urban districts, 11 county-level cities, and 80 counties.

According to data as of the end of 2023, Shanxi Province has a permanent population of around 34.66 million and a GDP of almost CNY 2,570 billion (Shanxi Provincial Bureau of Statistics, 2024).



Production of raw coal in cities of Shanxi Province in 2022 (unit: 10,000 tons)
Sources: Shanxi Statistical Yearbook 2023. Unit: 10,000 tons

Shanxi ranks first in China in terms of coal reserves and geographical distribution. Different from other coal-mining regions such as Inner Mongolia and Shaanxi, where coal reserves are highly concentrated in just a few regions, Shanxi sees its coal reserves widely scattered. According to the 2022 Statistics on National Mineral Resources Reserves released by the Ministry of Natural Resources, Shanxi's coal reserves were 48.31 billion tons, accounting for 23.3% of China's total and ranking first in China, closely followed by Inner Mongolia and Shaanxi with coal reserves of 41.12 billion tons and 29.10 billion tons respectively. Coal resources have been proven in 91 of the 117 county-level administrative units (urban districts, county-level cities and counties) in Shanxi, covering an area of 62,000 square kilometers, or 39.57% of the province's total area. The Shanxi Provincial Master Plan for Mineral Resources 2021-2025 proposes to develop three major coal production bases in Jinbei (northern Shanxi), Jinzhong (central Shanxi), and Jindong (eastern Shanxi), which will focus respectively on thermal coal, coking coal, and high-quality anthracite resources.

Figure 1-2 All cities in Shanxi Province have abundant coal resources, except for Yuncheng, which has relatively fewer coal resources and output. According to the statistics of 2022, 7 cities in the province had an annual coal production exceeding 100 million tons.

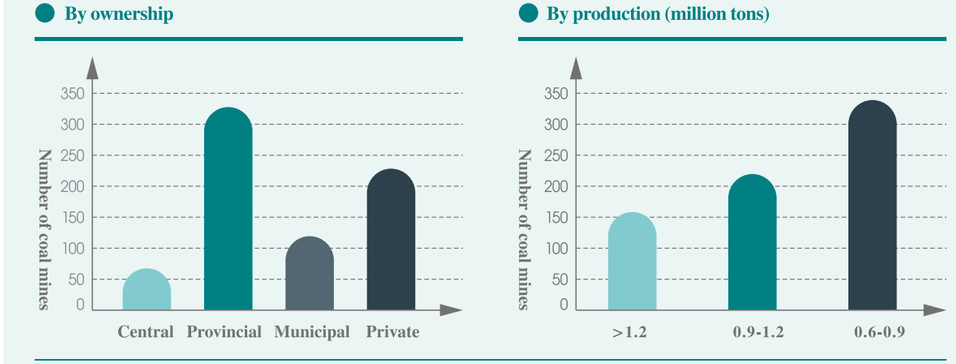


Figure 1-3 Coal mines in Shanxi Province by ownership and production in 2022
Sources: The List of Coal Mines released by Shanxi Provincial Bureau of Energy

Coal enterprises in Shanxi are mainly state-owned. The central government-owned, provincial government-owned and municipal government-owned enterprises account for nearly 70% of the total. According to the list of coal mines published by Shanxi Provincial Energy Administration in 2022, Shanxi Province has a total of 719 operating coal mines. Among these, central government-owned, provincial government-owned, municipal government-owned, and private coal mines account for 7.51%, 44.92%, 16.13%, and 31.43%, respectively. Coal enterprises with a capacity of more than 1.2 million tons account for 22.53%; those with a capacity of 900,000 tons to 1.2 million tons (excluding 900,000 tons) account for 29.62%; and those of 600,000 to 900,000 tons 47.98%[①].

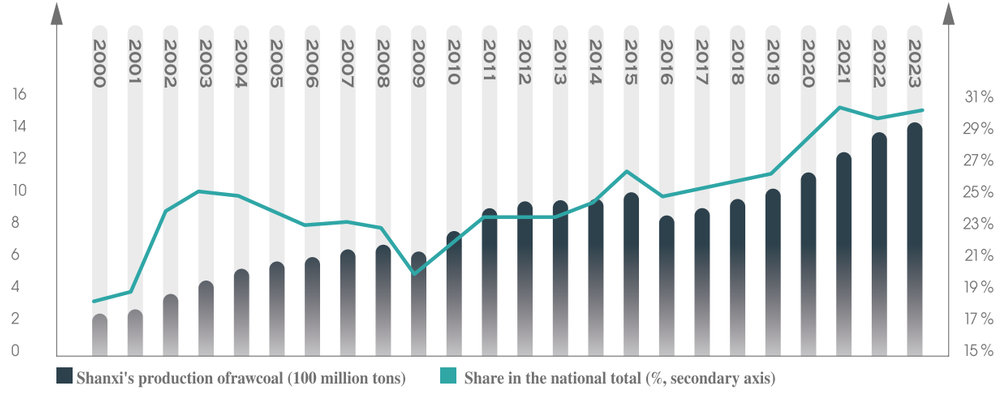


Figure 1-4 Shanxi's coal production and its share in China's total production (2000-2023)
Sources: Shanxi Statistical Yearbook, Statistical Communiqué of Shanxi Province on the 2023 National Economic and Social Development.

Shanxi is an important coal producer in China, with its production now reaching a plateau. Over the past four decades, Shanxi has been the largest coal producer and supplier in China. With its coal production accounting for more than 25% of China's total, Shanxi has more than 70% of its production shipped to other provinces. The province is also the largest coke producer and supplier in China. Over the past seven decades since the founding of the People's Republic of China, Shanxi has mined a total of 19.3 billion tons of coal and shipped 13 billion tons to other provinces. It has gone through the stages of rapid development, volatility and downturn, golden age of development, and supply-side reform. Shanxi's coal production is driven by domestic demand. China's rapid development over the past two decades has led to significant growth in coal production in Shanxi from 2000 to 2022. In 2020, Shanxi produced more than 1 billion tons of coal, returning to the top position in China. Since then, Shanxi has continued to be the largest coal producer in China. In 2023, Shanxi's coal output was 1.377 billion tons, accounting for about 29.24% of China's total production of raw coal, which was about 4.71 billion tons (China National Coal Association, 2024) and around 15.75% of the total global production, which was about 8.741 billion tons (International Energy Agency, 2023).

① The data is calculated based on the list of coal mines released by Shanxi Provincial Bureau of Energy.

02 COAL DEPENDENCE IN SHANXI PROVINCE

The phase-out of coal has varying social and economic impacts across regions, depending on resource endowment, economic structure, level of economic development, and significance of the coal industry to local employment (International Energy Agency, 2023). This study refers to and optimizes the Coal Transition Exposure Index (CTEI) of the International Energy Agency (IEA) based on Shanxi's conditions and evaluates its dependence on the coal industry mainly from four aspects, namely energy dependence on coal, level of economic development, economic dependence, and carbon assets.

2.1. Shanxi's Energy Dependence on the Coal Industry

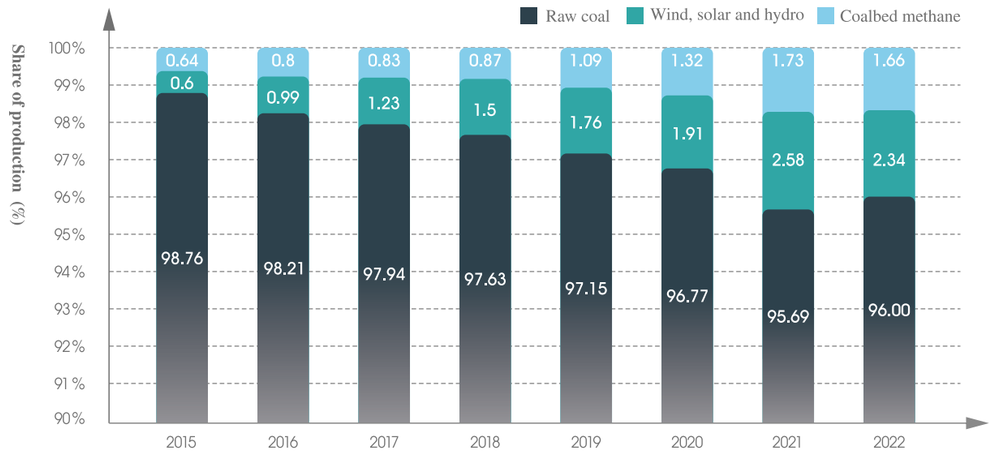


Figure 2-1 Primary energy production structure of Shanxi Province 2015-2022
Sources: Shanxi Statistical Yearbook; Statistical Communiqué of Shanxi Province on the 2023 National Economic and Social Development. Public data on Shanxi Province's energy production is only updated till 2022.

Shanxi Province is heavily dependent on the coal industry for energy production and consumption. It relies mainly on coal for energy production. As shown in Figure 2-1, the proportion of raw coal in primary energy production in Shanxi has long remained above 95%. Though it has dropped from 98.76% in 2015 to 96% in 2022 (with a slight rebound in 2022 compared to 2021), coal retains a dominant position in primary energy production in the province. In 2023, the installed capacity of coal-fired power in Shanxi Province was 72.063 GW, accounting for 54.17% of the total installed capacity, and the province's coal-fired power generation was 333.62 billion kWh, accounting for 74.8% of the total power generation (Shanxi Provincial Bureau of Statistics, 2024).

Primary industry Shanxi Province mainly relies on coal to meet its energy needs. In 2022, coal accounted for 80.56% of the total primary energy consumption of the province (Shanxi Provincial Bureau of Statistics, 2023), 24.36 percentage points higher than the national average (National Bureau of Statistics, 2023). The electricity and heat sector and the coking sector were the main coal consumers, accounting for 49.40% and 32.75% respectively and 82.15% totally of the province's coal consumption[2]. In 2022, Shanxi's coal consumption was 383.14 million tons. After reaching a record high of 7% in 2017, coal consumption growth rate gradually slowed down and fell to 2.5% in 2021, which was the first time it had been lower than the national coal consumption growth rate.

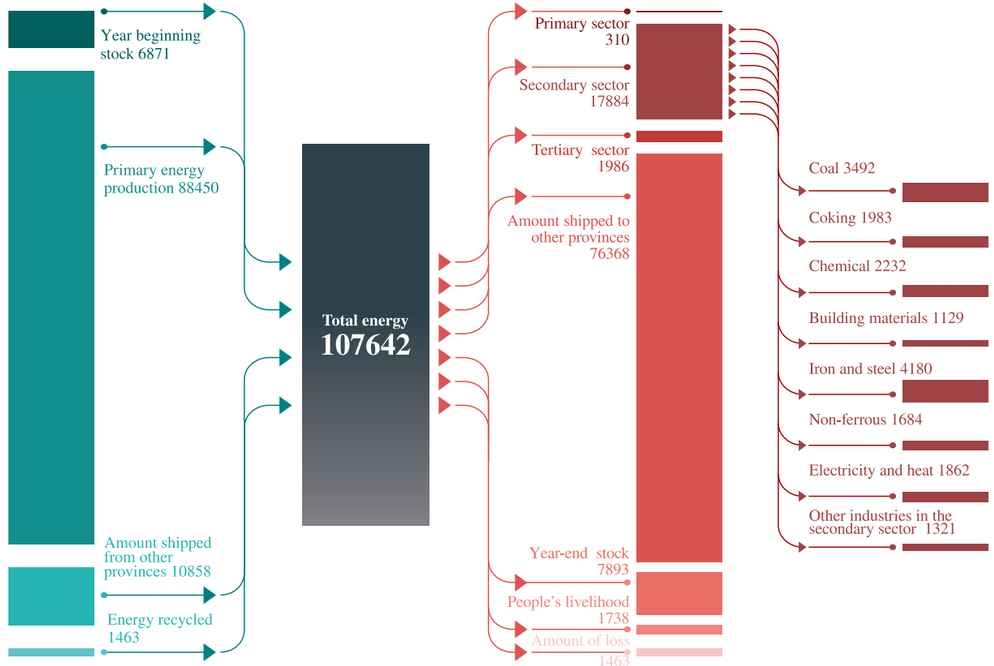


Figure 2-2 Energy flow diagram of Shanxi Province in 2022 (unit: 10,000 tons of standard coal)
Sources: Shanxi Statistical Yearbook 2023

2.2 Level of Economic Development

Shanxi has long ranked middle and lower among all the provinces in China in GDP terms. In 2023, Shanxi's share in the national GDP was 2%, ranking 20th in China; and its GDP per capita (CNY 73,984) (Shanxi Provincial Bureau of Statistics, 2024) was only 82.2% of the national level (CNY 89,358) (National Bureau of Statistics, 2024). From 2021 to 2023, Shanxi's annual real GDP growth rate reached 6.25% due to the soaring coal prices (Shanxi Provincial Bureau of Statistics, 2023). In 2024, as the coal industry experienced a downturn, the province's GDP growth rate dropped to 1.2% in the first quarter, far below the national average of 5.3% (Jiemian News, 2024), ranking last among the 31 provinces in China. In the meantime, its total economic output dropped by more than CNY 40 billion year on year (National Business Daily, 2024).

②Sources: Calculated based on Shanxi Statistical Yearbook 2023.

2.3. Shanxi's Economic Dependence on the Coal Industry

Shanxi's long-standing dependence on coal resources has led to its economy being closely interlinked to the coal industry. The secondary industry accounts for nearly half of the economic output of the province. And the pillar industry of the province is mining, which is dominated by coal mining. According to Shanxi Statistical Yearbook, 31.7% of Shanxi's GDP in 2022 was contributed by the mining industry and 15.3% by the manufacturing industry.

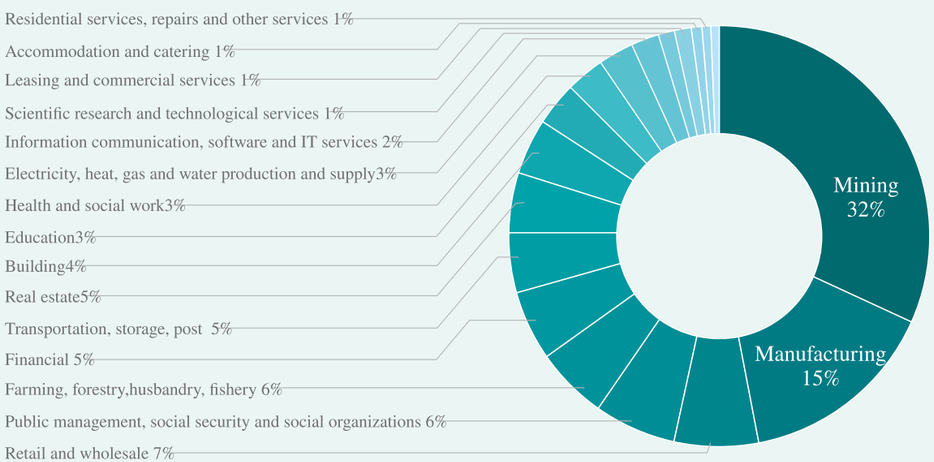


Figure 2-3 Shares of different industries in Shanxi Province's GDP in 2022
Sources: Shanxi Statistical Yearbook 2023

Shanxi Province, as an important energy base for China, plays an important role in ensuring energy security of China. In the past ten years, the amount of coal shipped out of Shanxi accounted for more than 70% of China's total inter-provincial transfers (China News Service, 2022). Most of Shanxi's coal is shipped to provinces like Hebei, Shandong, Jiangsu, and Henan. In 2023, Shanxi Province supplied 620 million tons of thermal coal to 24 provinces, accounting for 44.99% of its coal production. Besides, it supplied 157.6 billion kWh electricity to 23 provinces, accounting for 36.01% of its total power generation (Xinhua News Agency, 2024).

Figure 2-4 Coal shipped out of Shanxi Province in 2021
Sources: Professional Knowledge Service System for Energy

Note: There is no data on coal transferred to Hong Kong, Macau and Taiwan at present

Shanxi's economic dependence on the coal mining industry is higher than that of other major coal producers such as Shaanxi and Inner Mongolia. In 2022, Shanxi saw an operating income of CNY 1,642.63 billion from the coal mining and dressing industry, accounting for 42.07% of the province's industrial enterprises' revenue, and 40.33% of the revenue of the coal industry nationwide (CNY 4,072.94 billion), which was 1.25 times that of Inner Mongolia and Shaanxi (CNY 1,315.036 billion). The taxes contributed by the coal mining and dressing industry in Shanxi in 2022 reached CNY 172.773 billion, accounting for 72.77% of all taxes contributed by industrial enterprises in the province (Shanxi Coshare Innovation Institute of Energy & Environment, 2023).

	Shanxi	Inner Mongolia	Shaanxi
Share in the national coal production	29.25%	26.19%	16.16%
Share of coal shipped outside	59.96%	61.32%	60.81%
Share of revenue from the coal mining and dressing industry in the province's total industrial revenue	42.07%	23%	18.48%
Share of taxes contributed by the coal mining and dressing industry in the province's total industrial taxes	72.77%	N/A	N/A
Share of employment of the coal mining and dressing industry in the province's total industrial employment	21.49%	8.71%	4.28%

Table 2-1 Main coal-related economic indicators of the key coal-producing provinces in China
Sources: Calculated based on the Yearbooks 2023 and the Statistical Communiqué on the 2023 National Economic and Social Development of the provinces

The coal mining and dressing industry is a major employer in the industrial sector of Shanxi. In 2022, Shanxi's mining and dressing industry employed 926,400 people, accounting for 45.28% of the employment in industrial enterprises in Shanxi. This number was 2.55 times those in Inner Mongolia and Shaanxi (364,000), and its share in the total employment by the coal mining and dressing industry nationwide has been increasing each year (Shanxi Coshare Innovation Institute of Energy & Environment, 2023). In addition to direct employment, the coal mining and dressing industry also provides vast indirect upstream and downstream employment, such as machinery equipment, supplies and raw materials, and services from other industries. Energy transition will affect workers upstream of the coal industry chain through the factor-product relationship, amplifying the impact of coal phase-out on employment.

District / Year	Shanxi Province	China	Shanxi Province/China
2007	0.1461	0.0450	3.25
2012	0.2262	0.1130	2.00
2017	0.0543	0.0129	4.21

Table 2-2 Indirect employment coefficients of Shanxi Province and China

2.4 Carbon Assets Lock-in

Shanxi's coal-based development over the years will lead to long-term carbon lock-in in the future. At the same time, continued investment in carbon-related industries may also result in excessive burdens of stranded assets for the province. Relevant studies[3] show that in 2016, Shanxi ranked second in China in terms of carbon lock-in (Niu & Liu, 2021). In 2021, coal consumption in Shanxi contributed 93.85% of its carbon emissions(Shanxi Coshare Innovation Institute of Energy & Environment, 2023). Coal mining, coal power and coking are major carbon emission sectors in the province. An outlook of Shanxi's future carbon lock-in is provided below, based on the short-term development trends of these sectors.

Mining and dressing sector: The Outline of the 14th Five-Year Plan for National Economic and Social Development and the Long-Term Goals for 2035 of Shanxi Province issued by the People's Government of Shanxi Province proposes that during the 14th Five-Year (2021 – 2025) Plan period, Shanxi will rationally control the scale of coal development to stabilize raw coal production at about 1 billion tons. In recent years, Shanxi has taken various measures to improve the efficiency and increase production capacity of coal mines, including shortening and simplifying the application and approval process while extending the service life of mines (Shanxi Daily, 2023). In 2023, the province's coal production grew by another 57.43 million tons, after two consecutive years of growing by over 100 million tons.

and most efficient coal-fired power units. As one of the large-scale coal-fired power bases in China, Shanxi ranks top in China in installed coal-fired power capacity. It supplies electricity to the neighboring Beijing-Tianjin-Hebei region, Central China, and East China. The 2024 Government Work Report of Shanxi Province outlines that in 2024, Shanxi Province will accelerate the five coal-fired power projects which are under construction and complete the "three-transformation integration"[4] of coal power generators with capacity of 6.3 GW for energy-saving and decarbonizing, heat supply, and flexible utilization. According to the report Research on the Transition, Development and Positioning of the Coal Power Sector in Shanxi Province under the Carbon Neutrality Goal[5] , the total installed coal power capacity in Shanxi will maintain a certain level of growth in the short term and is expected to reach somewhere between 83 GW and 87 GW in 2030. Based on the average service life of 30 years and the inertial development path that operating hours remain unchanged, the coal-fired power generators newly built in recent years will impose a significant carbon lock-in effect in the future, which will bring great pressure on the realization of medium- and long-term carbon emission reduction goals.

Coking sector: As a coke production base in China, Shanxi ranks first in both coke production and the amount transferred to other regions. According to the national and provincial statistical yearbooks, Shanxi Province's coke production in 2022 was 97.997 million tons, accounting for 20.7% of China's total, of which 28.5% was consumed within the province and 71.3% was transferred to key steel-producing provinces and cities. The total coking capacity in Shanxi is expected to reach about 14.3 billion tons by the end of 2025 (Shanxi Coshare Innovation Institute of Energy & Environment, 2023), most of which will come from the large-scale coke ovens put into production during 2020 and 2025. Modern coke ovens can typically maintain continuous production (campaign life) for about 20 years. These coke ovens are projected to shut down around 2040. However, in view of the targets of Carbon Dioxide Peaking and Carbon Neutrality, the risks of carbon lock-in and stranded assets in the coking sector will both bring significant challenges to Shanxi's transition.

③ The RAGA-PP model, which integrates the accelerated genetic algorithm and the projection pursuit technology, aims to identify and analyze meaningful structures in high dimensional data. It effectively solves nonlinear problems by searching for statistically low dimensional projections and shows better performance than the traditional method of multivariate statistics. Besides, the RAGA-PP model can weight each indicator by determining the optimal projection direction to overcome the "curse of dimensionality" of high dimensional data, which avoids subjective interference, thus revealing data's structural characteristics more accurately. In application scenarios such as carbon lock-in assessment, the model can produce optimal predicted values and effectively indicate the level of carbon lock-in.

④ The "three-transformation integration" of coal-fired power generators refers to the transformation of three technologies namely energy-saving and decarbonizing, heat supply, and flexible utilization, which is carried out in an integrated manner, in the coal-fired power industry (Shanxi Daily, 2022).

⑤ The report was jointly released by Shanxi Coshare Innovation Institute of Energy & Environment and the Natural Resources Defense Council in 2022

03 IMPACTS OF COAL ON LOCAL SUSTAINABLE DEVELOPMENT

3.1 Environmental Impacts

The environmental impacts caused by coal mining and consumption are prominent in Shanxi. Decades of coal mining and burning has caused severe negative impacts on the environment, including water, land, atmosphere, and ecosystem, particularly land subsidence, earth fissures, land occupation and soil contamination. According to the latest investigation, there were 4,583 ground collapses and earth fissures in the province, accounting for 70% of China's mine-related geological disasters and potential hazards (Department of Natural Resources of Shanxi Province, 2019). An investigation by the Central Ecological and Environmental Protection Inspection team in 2023 revealed coal gangue stockpiles of 920 million tons (Taigu Bureau, Jinzhong Municipal Bureau of Ecology and Environment, 2023) across Shanxi, which occupied and polluted a large amount of land, reduced grassland, forest and cultivated land areas, and caused huge economic losses and ecological damage.

As estimated by the Research on Just Transition of Shanxi's Coal Industry under the Targets of Carbon Dioxide Peaking and Carbon Neutrality – A Special Report on the Coal Mining and Dressing Industry (Issue1)[6], the ecological and environmental losses to be caused by coal mining in Shanxi between 2025 and 2060 are shown in the table below. Besides, the industrial structure dominated by heavy chemical industries and the energy structure dominated by coal will take a toll on the environment. Pollutants from coal-related industries such as coking, steel, and coal burning will account for more than 80% of the total emissions of all industrial sectors and the bulk industrial solid waste stockpile in the province will exceed 1.4 billion tons, leaving Shanxi with overstretched ecological carrying capacity.

Items	Baseline policy scenario	Strengthening policy scenario
Water resource consumption and damage (100 million m^3)	575	425
Land occupied (km^2)	140	104
Land subsidence (km^2)	3939	2912
Soil erosion (km^2)	71491	52847

Table 3-1 Estimated ecological and environmental damage in Shanxi Province 2025-2060
Notes: The limitation of this estimated data is that the estimated ecological and environment damage is calculated based on the estimated coal production and the historical coefficient of damage caused in mining a ton of coal determined by former scholars. However, due to the lack of studies on influencing factors including the advancement of green mining technology, its qualitative and quantitative impacts on the ecological environment are still comprehensive and uncertain.

Massive amounts of methane are released in coal mining. According to the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC), methane's 20-year global warming potential (or warming effect) can be 84 times more powerful than carbon dioxide and its 100-year potential 28 times (IPCC, 2014). In 2018, the coal-related methane emissions in Shanxi reached about 5.13 million tons, accounting for about 20.42% of the national coal methane emissions in the same period. In 2023, the coal-related methane emissions in the province increased to 8.1969 million tons.

In recent years, the average annual temperature in Shanxi Province has continued to rise at a rate of 0.30℃ every decade. Especially since the start of the 21st century, it has witnessed eight of the ten warmest years that have occurred since 1961. Besides, since 2000, the average annual precipitation in Shanxi Province has increased significantly, with the average precipitation in the past decade (536.9 mm) exceeding the highest level in the 1960s (532.9 mm). Climate change has led to frequent extreme weather events in Shanxi, with increased heavy rainfalls and temperature drops, which in turn has increased the intensity of severe convection and temperature drops. Future climate change and rising temperatures will further aggravate disasters such as drought, hail, and rainstorm in Shanxi, and may increase the intensity of frost and low-temperature damage. Global warming will impose varying impacts on agricultural production of the province and the rich cultural heritage in this region (China News Service, 2024).

⑥The estimates of the ecological and environmental damage are determined based on estimated figures about coal production and the historical coefficient of damage caused in mining a ton of coal mentioned in some literatures.

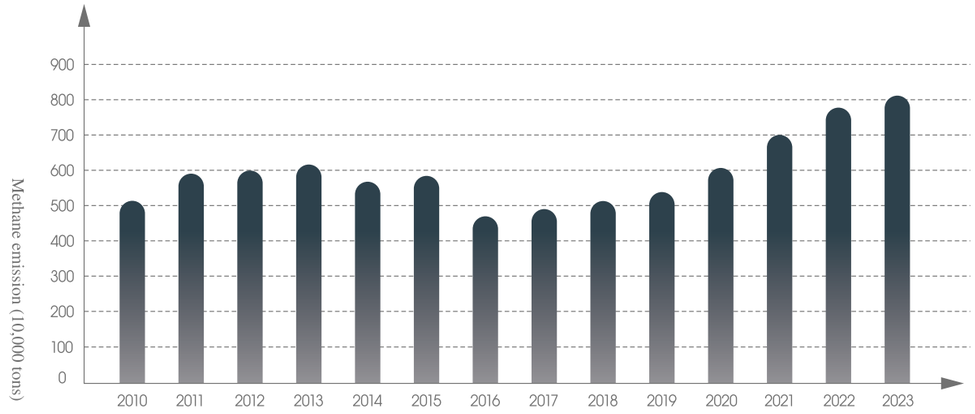


Figure 3-1 Coal-related methane emissions in Shanxi Province 2010-2023 (unit: 10,000 tons)
Sources: Calculated based on public data released by Shanxi Coshare Innovation Institute of Energy & Environment

3.2 Economic Impacts

The economy of Shanxi is vulnerable to volatility of the coal market, resulting in a lack of resilience. In recent years, coal industry's contribution to Shanxi's economy has continued to increase. In 2022, the share of revenue and taxes of the coal mining and dressing industry in the province's industrial sectors both reached their peak since 2010, generating an increase of 3% and 20% respectively compared to 2010. The economic growth takes on a simultaneous cyclical trend as coal price. The frequent declines and sharp fluctuations of Shanxi economy, closely in line with coal price volatility, shows a tremendous lack of diversity and therefore resilience. After decades of intensive coal mining, the province's economy now features only weak momentum for transition but strong hesitation or fear of transition.

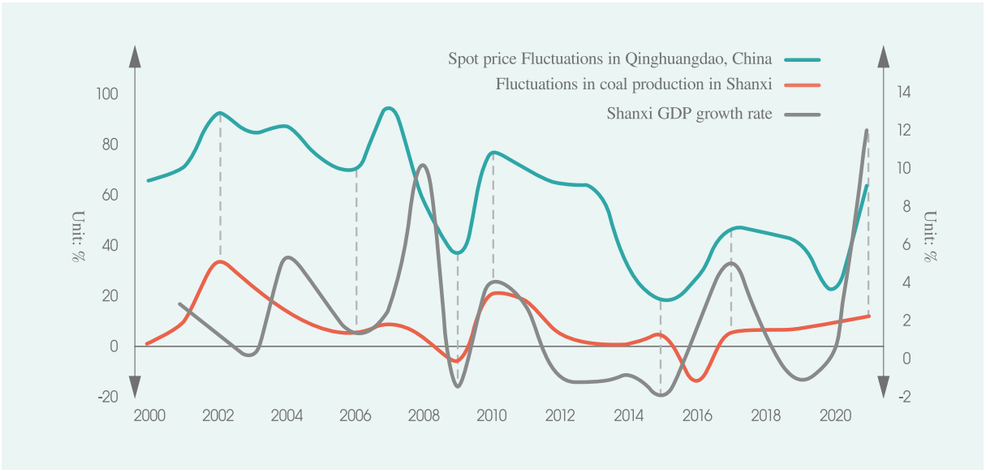


Figure 3-2 Being economically dependent on the coal industry, Shanxi Province's GDP is correlated with its coal production and coal market prices. Changes in coal production and GDP of Shanxi Province[7]
Sources: IEA, Shanxi Statistical Yearbooks (2001-2022)

⑦China's coal reserves are mainly located in North China. They are transported to ports by rail and then shipped to southern provinces by sea. The ports around the Bohai Sea, represented by Qinhuangdao Port, are important coal transshipment and distribution centers in China. The spot coal price at Qinhuangdao Port is the "barometer" of the coal market price in China.

Caught in the curse of resources, Shanxi is yet to diversify its economy. With the correlation between the coal industry and other industries continuing to weaken, the coal mining and dressing industry in Shanxi Province doesn't have obvious advantages in backward linkages. According to the 2017 Shanxi Province Input-Output Table, it is calculated that the share industrial value added of the coal mining industry in the province has exceeded 40%. However, in terms of influence coefficient and sensitivity coefficient, the coal mining and dressing industry ranked 24th and 37th respectively among the 42 industries in the regional economic system (Yang, 2023). The large scale of the coal industry has not brought growth to other industries. On the contrary, it has solidified the province's economic dependence on the coal mining and dressing industry. As a result of low industrial value added, long innovation cycle and severe damage to the environment during the conversion of coal resources into economic values, the conversion costs caused by the reliance of the industry on capital, environment and other production factors exacerbated the technological lock-in effect and hindered the flow of other production factors to other non-coal industries (Li, Ma, & Niu, 2020). As shown in Table 3-2, in recent years, Shanxi has continued to make investment in fixed assets in the coal industry, which further increased its economic dependence on the industry, making economic transformation and diversification more challenging. How to break the curse of coal resources, reduce dependence on the coal industry and promote economic diversification are important problems Shanxi needs to solve during its transition.

Year	Fixed assets investment in Shanxi's economy	Fixed assets investment in Shanxi's mining industry	Fixed assets investment in Shanxi's mining and dressing industry	Fixed assets investment in the mining and dressing industry nationwide
2016	1.00%	-25.32%	-26.62%	-24.18%
2017	-55.97%	-55.43%	-51.26%	-12.82%
2018	5.70%	-2.60%	6.30%	5.90%
2019	9.3%	19.5%	16.7%	29.60%
2020	10.6%	-7.2%	-13.0%	-0.70%
2021	7.3%	15.5%	10.3%	11.1%
2022	5.5%	11.9%	18.4%	24.4%

Table 3-2 Fixed assets investment in the coal industry

3.3 Social Impacts

As the coal industry is a predominant employer in Shanxi, energy transition will intensify the pressure from unemployment. Since 2019, the employment in the mining and dressing industry of Shanxi Province has rebounded year by year and has risen to 926,400, accounting for 45.28% of the national coal industry employment in 2022. The ratio of indirect employment coefficient to direct employment coefficient is 3.62 [8], nearly twice the national average. It means that people directly affected by the energy transition in Shanxi have much further connections with different industries, with more "vulnerable groups". Under the targets of Carbon Dioxide Peaking and Carbon Neutrality, taking into consideration the double effects from low-carbon and green energy transition and the increase in labor productivity, relevant reports predict that compared to 2022, the employment in the coal mining and dressing industry in Shanxi will drop by more than 40% at maximum. Without taking technological advancement into consideration, energy transition-related policies will reduce employment in the coal industry of the province to 9% of the current level by 2060. Coupled with technological upgrades, the share of the total employment in the coal mining and dressing industry of Shanxi Province will at least drop by another 7% or so (Shanxi Coshare Innovation Institute of Energy & Environment, 2024).

⑧The figure was calculated based on the 2017 Input-Output Table

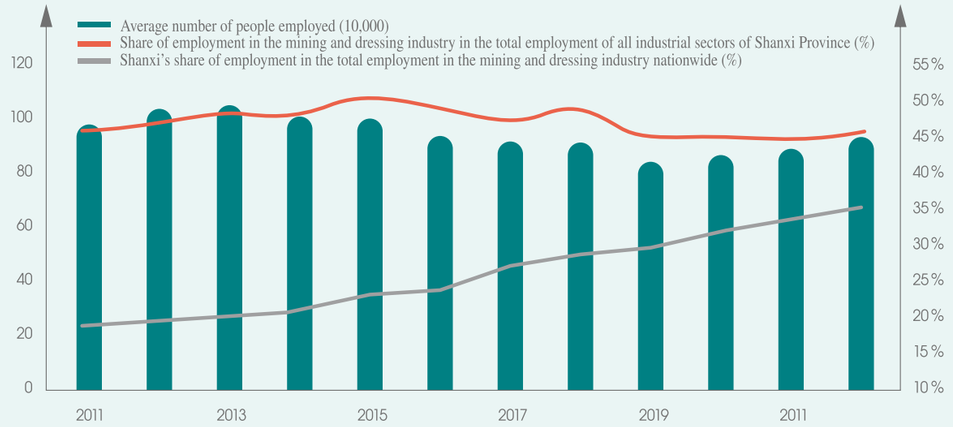


Figure 3-3 Changes in direct employment in the coal mining and dressing industry in Shanxi Province
From 2011 to 2021, as the average number of employees in the coal mining and dressing industry and the share of employment in all industrial sectors remained stable in Shanxi Province, Shanxi's share of employment in the total employment in the coal mining and dressing industry nationwide continued to rise.
Sources: Shanxi Statistical Yearbooks (2001-2023), China Statistical Yearbooks (2001-2023), and China Industry Statistical Yearbooks (2001-2016). Since some data is missing, Shanxi's share of employment in the national total employment in the coal mining and dressing industry in 2005 and 2012 was calculated by linear interpolation.

Coal mining and burning have severely polluted the environment, causing significant negative impacts on public health. Long exposure to pollutants from coal mining and burning will increase the prevalence of occupational diseases such as pneumoconiosis, noise-induced deafness, and silicosis. According to statistics on occupational hazards in key industries of Shanxi Province in 2019, 2,822 posts/types of work in the coal mining and dressing industry are highly exposed to intensive pollutants, of which only 72.86% are rated as passable in dust and hazardous air pollutant tests and 82.63% in noise tests (Cao, Wang, Ma, & Li, 2020). A study in 2017 on the prevalence of occupational diseases in key industries of Taiyuan, capital city of Shanxi, shows that coal dust and noise are the biggest hazards and mining is the industry with the biggest number of people exposed to these pollutants, accounting for 55.79% of the exposed people (Yan, Deng, & Li, 2019). Among the new cases discovered in 2017, there are 83 cases of coal workers' pneumoconiosis (CWP), a year-on-year increase of 38.33%, of which 77 cases are from the mining industry. Epidemiological surveys show that most of the people affected by CWP are dust-exposed workers over 40 years old. The incidence rate significantly increases if such workers have been exposed to coal dust for more than seven years, and the rate goes even higher among coal miners in closed mine shafts.

Coal mining and burning also have varying impacts on the physical health of ordinary residents in exposed areas. Coal burning leads to increased regional concentrations of SO_2 and particulates, which also increase the risk of respiratory and cardiovascular diseases among residents in the area. Coal burning in winter is the main source of particulates and SO_2 in Taiyuan City. It also leads to an increase in particulate concentration. When the concentrations of SO_2, PM_{10} and $PM_{2.5}$ increase by 10μg/m^3, the non-accidental mortality rates of the population increase by 1.00%, 0.64% and 0.66% respectively, those of the cardiovascular diseases increase by 1.03%, 0.99% and 0.75% respectively, and those of the respiratory diseases increase by 1.01%, 1.13% and 0.81% respectively (Sun, 2019). Since the harm of atmospheric pollutants caused by coal burning to human health is long-term and chronic, it is easily overlooked by the public. The impact on vulnerable groups, such as children, patients with chronic diseases and the elderly, is more significant. The average annual concentration of $PM_{2.5}$ in Shanxi Province dropped from 59μg/m^3 in 2017 to 37μg/m^3 in 2023 (The Information Office of Shanxi Provincial Government, 2024), the lowest level in history, but still higher than the national average (30μg/m^3). The average concentration of SO_2 (12μg/m^3) was 9μg/m^3 higher than the national average (Ministry of Ecology and Environment of the People's Republic of China, 2024). In the air quality ranking of 168 key cities across China in 2023, four of Shanxi Province's 11 prefecture-level cities were ranked among the bottom 20. Currently, Shanxi's air quality has been significantly improved. Nevertheless, to protect and improve the environment, the coal-dominated energy consumption structure still needs to be continuously optimized, and effective control of coal-related pollution is the key.

04 THE URGENCY OF A JUST ENERGY TRANSITION IN SHANXI

4.1 Pressure from Global and National Policies

In the global response to climate change, energy transition is accelerating. Since the Paris Agreement was signed in 2016, 195 parties have submitted their Nationally Determined Contributions (NDCs) (UNFCCC, 2021) and 151 countries have proposed their carbon neutrality targets (Tsinghua University, 2023). At the 26th United Nations Climate Change Framework Conference (COP26) held in Glasgow, UK, in 2021, UN Secretary-General Antonio Guterres called on developed countries to stop using coal by 2030 and other countries by 2040. More than 40 countries committed to phase out coal at the conference (BBC News, 2021), and 190 countries and organizations committed to gradually phase out coal-fired power generation (UNFCCC, 2021). At the COP28 held in Dubai, United Arab Emirates in 2023, nearly 200 parties reached consensus on "reducing the energy system's dependence on fossil fuels "in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science". At present, Austria, Belgium, Sweden, and Portugal have completely phased out coal-fired power generation, and Greece, the United Kingdom, Denmark and some other countries are significantly reducing the use of coal power, including major coal-consuming countries such as Germany and the United States (Jaeger, 2023).

In line with the global energy transition and climate change mitigation, China has published a series of policies to transform the energy structure and upgrade the coal industry, providing clear directions for the urgent transition of the coal industry and its future development. China's Action Plan to Achieve Carbon Dioxide Peaking and Carbon Neutrality states that coal consumption will be strictly controlled and gradually reduced, the share of non-fossil energy consumption is expected to increase to about 20%, and energy consumption per unit of GDP should be reduced by 13.5% and carbon intensity (carbon dioxide emissions per unit of GDP) should be cut by 18%, compared to 2020; by 2030, the share of non-fossil energy consumption should be increased to about 25% and carbon intensity should fall by more than 65%, compared to 2005 (State Council, 2021). In addition, the gradually maturing carbon market in China will have a potential impact on the coal industry in Shanxi Province. The coal market will impose bigger challenges for coal enterprises in balancing economic growth and environmental protection. With the launch of the national emissions trading system (ETS), enterprises that fail to meet the carbon emission requirements will need to purchase carbon credits, which will increase their operating costs. In a market environment where coal prices are already under pressure, additional carbon emission costs will further squeeze the profit margins of coal enterprises.

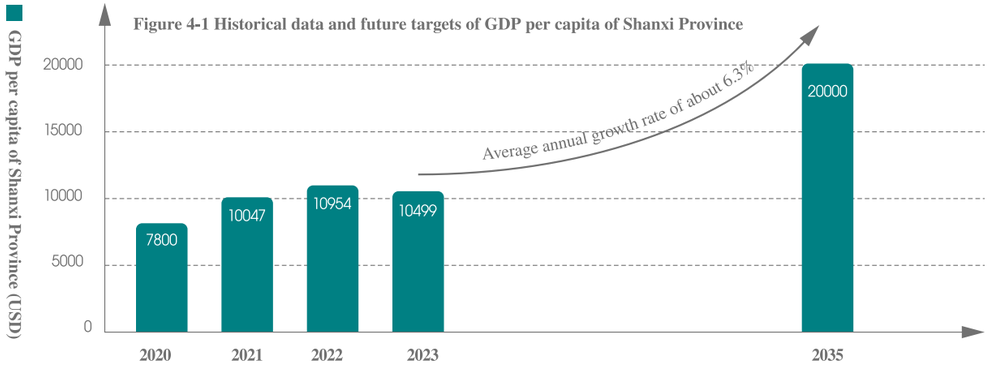
4.2 The Local Need for Sustainable Development

The Action Plan of Shanxi Province for Carbon Dioxide Peaking printed and published by the People's Government of Shanxi Province outlined that during the 14th Five-year Plan period, the province shall promote the clean and efficient utilization of coal and strictly curb the growth of coal consumption. By 2025, the share of non-fossil energy consumption of the province shall reach 12% and that of installed capacity of new energy and clean energy shall reach 50%, and the share of electricity production using such energy shall increase to 30%. By 2030, the share of non-fossil energy consumption of the province shall reach 18% and that of installed capacity of new energy and clean energy shall exceed 60%. By 2025, the average coal production of each mine in Shanxi should be elevated to more than 1.75 million tons/year, with the number of coal mines dropping to about 820[9] and the share of advanced production capacity reaching about 95%.

The urgency of economic diversification has been highlighted. In recent years, Shanxi Province has issued several policies such as the High-quality Development Plan for the Central Shanxi Urban Agglomeration (2022-2035), the Implementation Plan for the Working Mechanism of Key Industrial Chains and Industrial Chain Leaders in Shanxi Province, the 14th Five-Year Plan of Shanxi Province for 14 Strategic Emerging Industries, and the 14th Five-Year Plan of Shanxi Province for Future Industrial Development to promote high quality transition and diversification of Shanxi's coal-based economy. Some emerging industries are growing fast. In 2023, the values added of energy saving and environmental protection industries and comprehensive utilization of waste resources above designated scale in Shanxi Province increased by 32.9% and 65.6% respectively, and the production of computers and photovoltaic cells increased by four times and 21% respectively. But overall, the mining industry is still a key industry driving economic growth in Shanxi Province. To speed up transition, Shanxi must promote the high quality development of non-coal industries to replace the coal industry and adjust the industrial structure dominated by the coal industry.

There are strong endogenous demands for economic and social development. According to the Outline of the 14th Five-Year Plan for National Economic and Social Development and the Long-Term Goals for 2035 of Shanxi Province, GDP per capita should reach USD20,000 by 2035, roughly keeping up with the development rate as the rest of China. To this end, Shanxi Province needs to maintain an annual economic growth rate of 6.3% in the next ten years. It must maintain a growth rate higher than the national average while achieving high quality development. Currently, the industrial structure of Shanxi is heavily dependent on energy and heavy industries. In the context of the global climate action and the impacts of the coal market, Shanxi's economic development is volatile and vulnerable to external risks, bringing great challenges to both balanced development and emission reduction.

Figure 4-1 Historical data and future targets of GDP per capita of Shanxi Province



More efforts will be needed for ecological restoration. In recent years, Shanxi Province has published a number of policies such as the Plan for the Development and Utilization of Mineral Resources, Mine Environmental Protection and Land Reclamation in Shanxi Province, the Administrative Measures of Shanxi Province for Ecological Restoration of Historical Mines, and the Specification for Mine Restoration in Shanxi Province, all of which have outlined the long-term and short-term goals for environmental improvement in the province. Shanxi Province aims to bring about continuous environmental improvement through 2025 and restore ecological damage by mid-21st century. However, there still remain key challenges such as lack of funds, insufficient technological support, undeveloped supervision mechanism, lack of information transparency and low public engagement in ecological restoration. To achieve its ecological targets, Shanxi Province must accelerate the transition of the coal industry, develop new quality production forces, alleviate pressure on ecological restoration, reduce environmental damage, and achieve environmental sustainability.

⑨ According to the Notice on the Publication of the 2024 Annual Classification List of Coal Mines issued by the Office of the Shanxi Provincial Safety Production Committee, there are a total of 888 coal mines of various types in the province.

05 TRANSITION EFFORTS AND ACTIONS

5.1. Transition at the Policy Level

The Carbon Dioxide Peaking and Carbon Neutrality policies and other relevant policies issued by Shanxi Province focus on the comprehensive green transition of energy, economic and social sectors, aiming to achieve a clean, low-carbon, secure and efficient modern energy system and to complete the transition of the resource-based economy by 2030. To realize just energy transition, Shanxi Province has formulated a series of policies for energy transition, support to workers, alternative industry development and living quality improvement.

Energy transition is being carried out in a top-down approach to create a low-carbon and green new energy system.

The energy-related policies of Shanxi focus on the high-quality development of the coal industry and the replacement of coal with new energy, promoting energy transition in terms of energy supply, consumption, technology and rules and regulations. To promote the high−quality development of the coal industry, Shanxi Province has made concerted efforts in key areas such as clean and efficient utilization of coal resources, production structure upgrade, development optimization, industrial chain extension, and coal market improvement. Through measures on "smart"coal mines[10], green mining[11], zero carbon mines[12], and "five integrations"[13], Shanxi has made efforts to improve efficiency and to reduce carbon emissions of the coal industry. At the end of 2023, the share of advanced coal production capacity in Shanxi Province exceeded 80% and 281 coal mines with intelligent mining facilities were established. To accelerate the development of new energy industries, Shanxi Province strives to build a new energy system which is based on new energy, with efforts centering on all processes including new energy development, supply, storage, adoption and consumption and utilization. By taking measures such as enhancing the industrial supply chain, promoting storage, adoption and consumption, accelerating the market-oriented reform, developing the whole energy industrial chain, building an intelligent energy system and stepping up carbon offset transition as well as establishing a modern energy industry system, the province set the goals to increase renewable energy installed capacity to more than 83 GW, with new energy and clean energy accounting for 50%, by 2025. In 2023, 9.586 billion kWh of electricity generated by new energy was transmitted out of the province, increased by 14.95% year on year, of which 2.311 billion kWh was green electricity, benefiting Beijing, Tianjin, Shanghai, Jiangsu and Zhejiang (Shanxi Daily, 2024). In April 2024, Shanxi's share of new energy installed capacity was 1.1 percentage point higher than the national average (Central Government of the People's Republic of China, 2024).

⑩ The development of "smart" coal mines refers to the establishment of an intelligent system with comprehensive perception, real-time interconnection, analysis and decision-making, autonomous learning, dynamic prediction, and collaborative control through deep integration of AI, industrial Internet of Things, cloud computing, big data, robots, intelligent equipment, etc. with modern coal development and utilization, so as to realize smart operations throughout coal mine development, mining (stripping), transportation, ventilation, dressing, safety assurance, operation and management, which is of great significance to improving the production safety of coal mines and ensuring the stable supply of coal (National Development and Reform Commission, 2019).

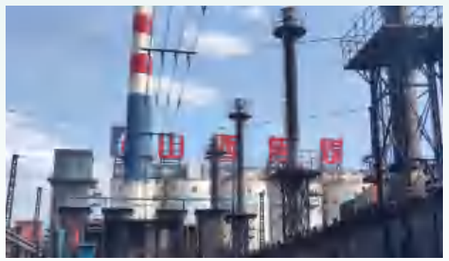
⑪ Green mining refers to a mining method that takes the protection of both various resources and the environment into comprehensive consideration in the coal mining process. Based on its basic concept of understanding and utilizing various resources such as coal, gas, groundwater, land, and gangue from the perspective of resources in a broad sense, green mining minimizes the negative impacts of coal mining on the environment and other resources by controlling or utilizing the fracture movement of the mining bed, ultimately achieving efficient resource utilization and coordinated environment development (Xu, 2020).

⑫ Zero carbon mines refer to mines that achieve zero carbon dioxide emission through integration of technologies in multiple fields such as energy-saving and carbon reduction, zero-carbon energy supply, gas utilization, and ecological carbon sink with innovative management practices by digital means (Shanxi Daily, 2024).

⑬ "Five integrations", a concept raised in the Opinions on Carrying out the Pilot Project on Comprehensive Reform of Energy Revolution in Shanxi Province, refers to the integration between coal and coal-fired power, coal-fired power and new energy, coal and coal chemistry, coal industry and digital technology, and coal industry and carbon reduction technology.

Case 1 **Shanxi Province, a big coal power supplier, fired the first shot in the national electricity spot market**

The Carbon Dioxide Peaking and Carbon Neutrality targets make it an imperative to build a unified national power market, drive the transition of the power industry, and promote the sharing, exchange and better allocation of power resources on a larger scale across the country, so as to improve the stability and flexibility of the power system and achieve clean and low-carbon energy transition and high-quality development at a lower cost through market-based means (People's Daily Online, 2022). Shanxi is one of the first eight pilot provinces for the construction of the national electricity spot market. Officially put into operation on December 22, 2023, the electricity spot market of the province is the first that was officially put into operation in China. This is an important milestone in the construction of both Shanxi's and China's electricity markets. It has also laid a solid foundation for Shanxi Province to further explore the construction of the electricity market system under the new power system. The construction of the electricity spot market is of great significance in reducing electricity costs, improving the autonomy of market players, promoting better allocation of resources, and helping to achieve the Carbon Dioxide Peaking and Carbon Neutrality goals. Shanxi Province is currently accelerating the improvement of the stability and flexibility of the power system, striving to achieve clean and low-carbon energy transition and high-quality development at a lower cost through market-based means.



Support for transition of coal industry workers is essential to ensure a just transition.

Affected by multiple factors such as the advancement of industrial technology, fluctuation of market prices, and depletion of some coal mines and coal reserves, Shanxi Province has published several employment policies in relation to the energy industry as a pilot for coal-based regions to support overall capacity reduction and integration and efficiency improvement at coal mines, by creating job opportunities, strengthening technical training, improving social security connection, and providing backup public welfare posts for the workers. During the capacity reduction period, Shanxi Province explored various ways of placement to meet the reemployment need of layoffs from the coal industry: internal retirement and internal transfer within coal enterprises; employment opportunities outside coal enterprises, such as job transfers and labor export, entrepreneurship, and public welfare positions. In 2016 and 2017, Shanxi Province recorded placement rates of 99.6% and 88.6% respectively during the capacity reduction period. During the 13th Five Year Plan period, it replaced 118,000 workers affected by the capacity reduction of the coal industry (CPC News, 2019).

Case 2 **Coking Coal Group established a human resources company**

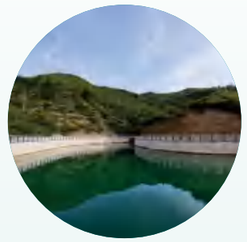
During the capacity reduction period, Shanxi Coking Coal Group expanded employees' re-employment channels, alleviated employees' worries, and enhanced incentives to ensure smooth re-employment transition by encouraging the workers to look for alternative jobs while retaining their positions without pay. The company set up a human resources company, and established a "mass entrepreneurship and innovation" base in June 2016, with 42 companies settled in the base area, involving electronic information, aerospace technology, Internet+, cultural media, human resources and other sectors. Through cooperation with Shanxi Transformation and Comprehensive Reform Demonstration Zone, Suzhou Industrial Park and Tianjin Economic-Technological Development Area and other organizations, the group provided approximately 8,034 positions for laid-off employees through job fairs, entrusted recruitment, etc (State-owned Assets Supervision and Administration Commission of Shanxi Provincial Government, 2017). At the end of the year, the group invested CNY 20 million and took the lead in establishing "Shanxi Coking Coal Human Resources Co., Ltd.". By creating a third-party supply and demand platform, it achieved better allocation of human resources by only employing people needed to improve the quality and efficient of employment. It also engages in businesses such as export of labor services, service outsourcing, labor dispatching and technological services (State-owned Assets Supervision and Administration Commission of the State Council, 2018), thereby improving the mobility of employees and the efficiency of human resource allocation, providing support for employees to reintegrate into and match the labor market.

Land is restored in affected areas to improve the quality of life in the community.

Shanxi Province improved the entire process mechanism for ecological restoration, specified the responsibilities of the government and enterprises in all aspects such as damage evaluation, planning, capital reserve and land reuse. At the same time, it enhanced capacity building in environmental supervision, such as laws, regulations, standards, and statistical monitoring indicators, and established quantifiable and standardized criteria for ecological restoration assessment. Shanxi Province was the first in China to formulate the Mineral Resources Development and Utilization Plan, the Mine Geological Environment Protection, Governance and Restoration Plan, the Mine Ecological Environment Protection, Governance and Restoration Plan, and the Land Reclamation Plan, which were jointly compiled into the Plan for the Development and Utilization of Mineral Resources, Mine Environmental Protection and Land Reclamation in Shanxi Province (Department of Natural Resources of Shanxi Province, 2021) to integrate and standardize the preparation of plans for all aspects of ecological restoration.

Case 3 The "Xishan Model" of Taiyuan City for Green and Sustainable Development

"Clear waters and green mountains are invaluable assets". As one of the first national innovation demonstration zones for sustainable development agenda, Taiyuan City closely focused on the theme of "transforming and upgrading resource-based cities" and launched coal mine ecological restoration in Xishan area. It has creatively adopted the sustainable development strategy of "ecological restoration guided by the government and executed by enterprises". The "20+80" policy was introduced to expand green land with every 80 units of damaged land restored and the said enterprises get 20 units of extra land for development. Through institutional innovation, it has effectively attracted social capital to engage in sustainable ecological restoration, environmental governance and industrial transformation, and formed the "Xishan model" where "ecological protection is balanced with economic development, clear waters and green mountains are developed for both ecological and economic values, and benefits of ecological civilization and material civilization are shared". Since the implementation of environmental governance in 2008, afforestation covering a total of more than 200,000 mu (about 13,333.33 hectares) has been completed, and more than 10,000 mu (about 666.67 hectares) of destroyed area has been restored, generating total tourism revenue accounting for 25% of the city's total (The Information Office of Taiyuan Municipal Government, 2024), playing an important role in improving environmental quality, enhancing residents' sense of happiness, creating employment opportunities, promoting economic growth, and achieving rural revitalization. The "Xishan model" was included as a typical case in the China's Progress Report on Implementation of the 2030 Agenda for Sustainable Development (2021), shared at the United Nations, and has been widely recognized both at home and abroad. In October 2023, Xishan Demonstration Zone was identified by the Ministry of Ecology and Environment as the seventh batch of national practice and innovation bases for the "Clear Waters and Green Mountains" initiative. In the future, the zone will follow the development strategy of "strengthening its leading role, extending its chains, and building clusters", focus on the five major industries of low-carbon ecology, cultural tourism, health and wellness, sports and leisure, and scientific and technological research and development, and embark on a green development path with beautiful ecology, prosperous industries, and rich people (Xinhua News Agency, 2023).



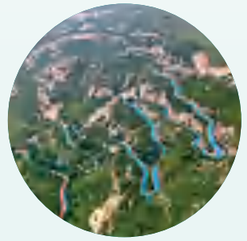


Table 5-1 Just Transition Policies of Shanxi Province

Policy Type		Policy Name
Energy transition	Low-carbon coal transition	2024 Work Plan of Shanxi Province for Stabilizing Coal Production and Supply (J.Z.B.F. [2014] No.15) Notice on Further Accelerating the Comprehensive Utilization of Low-concentration Gas in Coal Mines (J.F.G.N.Y.F. [2024] No.7) Implementation Plan for the Comprehensive Promotion of Intelligent Coal Mines and the Construction of Coal Industry Internet Platform (J.Z.B.F. [2023] No.27) Regulations of Shanxi Province on Promoting Clean and Efficient Utilization of Coal (adopted at the 38th meeting of the Standing Committee of the 13th People's Congress of Shanxi Province on December 9, 2022)
	Renewable energy development	Three-Year Action Plan of Shanxi Province for Promoting the Development of Distributed Renewable Energy (2023-2025) (J.Z.B.F. [2023] No.5) Notice on Issuing the Medium- and Long-Term Development Plan of Shanxi Province for the Hydrogen Energy Industry (2022-2035) (J.F.G.G.X.F. [2022] No.308)
	New electric power system building	Notice on Issuing the Measures of Shanxi Province for the Operation and Management of the Electricity Market (J.Z.B.F. [2022] No.87) Implementation Plan for the Construction and Operation Management of Virtual Power Plants (J.N.Y.G. [2022] No.1)
Support for transition of coal workers	Re-employment	Several Opinions on Promoting Harmonious and Stable Labor Relations in State-owned Enterprises (J.R.S.T.F. [2022] No.45) Notice of the General Office of the CPC Shanxi Provincial Committee and the General Office of the People's Government of Shanxi Province on Further Improving Work Stability and Ensuring Employment (T.Z. [2022] No.29)
	Training	Implementation Opinions of Shanxi Province on Vocational Skills Training (2022-2025) (J.J.N.B. [2022] No.1) Action Plan of Shanxi Province for Promoting the Reform and Development of Vocational Education (J.Z.F. [2020] No.19)
	Social security	Notice on Strengthening Work Concerning the Minimum Living Security (J.M.F. [2023] No.31) Opinions on the Implementation of Reform and Improvement of the Social Assistance System
Alternative industry development	Development of the cultural tourism and healthcare industry	Implementation Plan for Accelerating the Construction of Cultural Tourism and Healthcare Clusters and Demonstration Zones in 2024 (J.W.L.F. [2024] No.7) Implementation Opinions of the People's Government of Shanxi Province on Promoting the High-quality Development of the Cultural Tourism Industry (J.Z.F. [2024] No.2)
	Modern logistics	Implementation Plan of Shanxi Province for Accelerating the Integrated Development of E-commerce System, Express Logistics and Distribution System (J.Z.B.F. [2023] No.10)
	Modern agriculture	Notice of the Office of the Department of Agriculture and Rural Affairs of Shanxi Province on Issuing the Work Plan of Shanxi Province for the Establishment of a National Standardized Whole-Industrial-Chain Demonstration Base for Modern Agriculture
	New materials	2024 Action Plan of Shanxi Province for Developing the Special Steel Materials Industry Chain
	Bioeconomy	2024 Action Plan of Shanxi Province for the Modern Pharmaceutical Industry Chain
	Business environment	Notice on Issuing the Action Plan of Shanxi Province for 2024 - The Year of Deepening Business Entities (J.Z.B.F. [2024] No.13)
	Industrial chain extension	2024 Action Plan of Shanxi Province for the "Chain Leader System" for Key Industrial Chains Implementation Plan for the Working Mechanism of Key Industrial Chains and Industrial Chain Leaders in Shanxi Province
Community elevation	Infrastructure	Three-Year Action Plan of Shanxi Province for New Infrastructure Construction (2021-2023)
	Mine Ecological Restoration	Plan of Shanxi Province for Ecological Protection and High-quality Development of the Yellow River Basin (J.Z.F. [2023] No.5) Implementation Measures of Shanxi Province to Encourage and Support Social Capital to Participate in Ecological Protection and Restoration (October 2022)
	Placement of immigrants	Several Opinions of the General Office of the People's Government of Shanxi Province on Further Improving the Work of Relocation and Resettlement for Poverty Alleviation (J.Z.B.F. [2017] No.91)
	Public services	Implementation Plan of Shanxi Province for Improving Medical Quality in an All-round Manner (2023-2025) Five-Year Action Plan of Shanxi Province for Accelerating the Building of Shanxi into a Province with Strong Transportation (2023-2027)

5.2. Transition at the Industry Level

Low-carbon comprehensive utilization of coal bed methane (CBM).

Shanxi is rich in CBM resources. The amount of CBM reserves at the depth of less than 2,000 meters account for nearly one-third of China's total (China Energy News, 2023). Shanxi was established as a pilot province for the reform of approval of the CBM mining rights in 2016. It issued the first provincial-level special plan for CBM exploration and development in China in the following year. In recent years, the province has become one of the important CMB bases in China. Between 2019 and 2023, its production of CMB increased from 6.4 billion cubic meters in 2019 to 11.3 cubic meters in 2023, maintaining a share of over 70% in the national total. In the future, Shanxi Province will continue to promote the large-scale and commercial development of the CBM industry, and strive to realize the production goal of 20 billion to 25 billion cubic meters by 2025 (The People's Government of Shanxi Province, 2023).

Exploitation of both coal and CBM to improve the utilization efficiency of coal mine gas.

Shanxi promoted the extraction and utilization of coal mine gas, transforming the gas that originally threatened the safety of coal production into fuel for production and life, thus creating both environmental and economic benefits. Changping Coal Mine and Baode Coal Mine in Jincheng City, Shanxi Province have been included by the National Energy Administration in the first batch of demonstration projects in China for efficient extraction and utilization of coal mine gas (specifically for extraction), while Daning Coal Mine and Lu'an Gucheng (ancient town) Coal Mine have been included in the first batch of demonstration projects for efficient extraction and utilization of coal mine gas (specifically for utilization). In 2022, the volume of gas extracted in Shanxi Province was 6.3 billion cubic meters and the volume of utilized gas 2.92 billion cubic meters, with an extraction-utilization rate reaching about 46% (Shanxi Provincial Bureau of Statistics, 2023). The Guideline on Comprehensive Utilization of Coal Mine Gas sets the 2025 50% target of gas utilization, so as to further improve the efficiency of gas utilization.

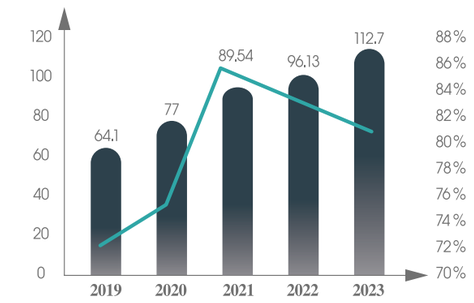


Figure 5-1 Coal bed methane production in Shanxi Province increased year by year 2019-2023
Sources: Shanxi Provincial Bureau of Energy
Production (100 million cubic meters)
Share in the national total (%, secondary axis)

Case 4 Comprehensive and efficient utilization of gas in Sihe Coal Mine of Shanxi Jincheng Anthracite Mining Group Co., Ltd.

Located in Qinshui Basin, Sihe Coal Mine under Shanxi Jincheng Anthracite Mining Group Co., Ltd. in Shanxi Province is a gassy mine with a huge gas capacity of tens of millions of tons. The absolute gas outburst volume reaches 1,665 cubic meters per minute, which is now used by Sihe gas power plant. Sihe Coal Mine actively promotes gas governance and comprehensive utilization. Through exploitation of both coal and CBM from both above and under the mine, it has achieved full coverage of CBM spot checks throughout the coal production from stages before, during and after mining. Underground, Sihe Mine has effectively improved gas extraction efficiency and underground safety through the application of technologies such as long-distance fixed-point sealed coring technology, gas control technology for ultra-thin coal seams, and large diameter hole steering drilling technology. On the ground, it has adopted technologies such as Guangli online monitoring devices and evaluation system for unit gas extraction to fully grasp mine information, integrating data and information right away through digital technology and promoting the comprehensive utilization of gas enabled by science and technology. From 2018 to 2021, the volume of gas extracted by Sihe Coal Mine remained at about 800 million cubic meters, reducing carbon dioxide emissions by 12 million tons every year. It has not only realized low-gas mining in the gassy mine, but also provided strong guarantees for the company's diversification and green development (China Environment Supervision, 2022). Sihe Gas Power Plant is currently the largest gas power plant in the world. In 2014, the installed capacity of the plant was 120 MW, consuming about 200 million standard cubic meters of CBM each year, which could reduce carbon dioxide emissions by more than 3 million tons. Compared with coal-fired power plants of the same capacity, it saved 290,000 tons of standard coal (State-owned Assets Supervision and Administration Commission of the State Council, 2014). In addition, Sihe Coal Mine has also taken the initiative in promoting sewage treatment and ecological restoration and widely spread its experience in comprehensive gas utilization to promote green and sustainable development in the gas field throughout the province and the country.

"Zero-carbon mines" for a clean and low-carbon energy system

Shanxi is actively promoting the "zero carbon" (near zero carbon) development of the coal industry. The Implementation Plan of Shanxi Province for Creating a Zero Carbon (Near Zero Carbon) Industry Demonstration Zone outlines that Shanxi aims to build 5 zero-carbon mines, with the focus on advanced coal mines with large production capacity, by 2025. The province also plans to reduce the carbon dioxide emissions per ton of raw coal by more than 20% compared with 2020. And by 2030, zero carbon emissions are expected to be achieved in "zero-carbon mines" (China Power News Network, 2023).

Case 5 Malan Coal Mine of Xishan Coal Electricity built a "zero carbon mine"

Malan Coal Mine of Xishan Coal Electricity, a subsidiary of Shanxi Coking Coal Group, is one of the first pilot enterprises of "zero-carbon mines" in Shanxi Province. So far, the mine has upgraded some infrastructure, such as energy-saving transformation of electromechanical equipment, comprehensive utilization of gas, exploration of the "green electricity + ecology" model, and the construction of intelligent mines. Through digital means, Malan Coal Mine has successfully integrated energy-saving and carbon-reduction technologies with zero-carbon energy supply technologies to create a unique "zero-carbon mine" operating model. At present, the rate of gas utilization in the mining area has been increased to 54%, and the share of vehicle electrification has reached 94.34%. In terms of information management, Malan Coal Mine actively promotes the construction of a carbon emission information platform and has built a complete carbon emission management system for coal enterprises. The system consists of several core sections including overall review, data filling and reporting, and carbon emission management, providing strong support for environmental protection management of the coal mine. At the same time, to strengthen the management of the gangue yard, the mine installed video surveillance equipment in the yard, imposing full-process dynamic monitoring on the yard operation, which effectively prevents the occurrence of environmental emergencies. In terms of ecological restoration and environmental governance, the mine actively promotes the ecological restoration project of the west platform of the Hutougou waste dump, the fully enclosed construction of the cement depot, and the dust control projects of the secondary inclined shaft square and the lumberyard. In addition, it also actively explores new energy projects, such as photovoltaic power generation and utilization of waste heat from gas power generation, to further promote the green and low-carbon development of the mine (Shanxi Worker's Network, 2024). In addition, Malan Coal Mine also takes the initiative in fulfilling its social responsibilities by carrying out publicity and education activities on green production and carbon emission management to improve the environmental awareness of its employees and local residents. The initiatives carried out by Malan Coal Mine on building the "zero-carbon" mine not only improved the environmental protection capabilities of the company, but also provided valuable practical experience in and demonstration for low-carbon transition of the coal industry. Malan Mine has set a short-term goal of forming a comprehensive, mature, green and low-carbon technology and management system by 2025, which is expected to reduce carbon emissions by 74,100 tons; it has also set a long-term goal to fully build a pilot "zero-carbon mine" demonstration mine by 2030, and planned to promote it in Shanxi Province and even nationwide, which is expected to reduce carbon emissions by 141,800 tons in total (Xishan Coal Electricity, 2024).

Development and utilization of hydrogen energy

The Shanxi provincial government have listed the hydrogen energy industry chain as one of the ten key industry chains to be greatly developed, and they have established a "six-in-one" work structure which clearly outlined that by 2025, Shanxi Province will initially build a hydrogen energy supply system that mainly utilizes industrial by-product hydrogen and renewable energy-based hydrogen in the neighboring regions. Data from 2023 shows that Shanxi Province's hydrogen energy index is 598.34, ranking first among the major hydrogen energy development regions in China; and its comprehensive index of hydrogen energy industry development is 285.05, ranking second among such regions (The People's Government of Shanxi Province, 2017). At present, Shanxi has formed a hydrogen energy industry chain covering multiple processes such as hydrogen production, storage (transportation), refueling, fuel cell systems and hydrogen fuel vehicles. It is accelerating the development of the province into a national hydrogen energy supply and trade center, a high-end industrial manufacturing base, and a demonstration zone, with a final goal of building it into a new highland for the development of China's hydrogen energy industry with demonstration effects at home and influence in the international market.

Case 6 **Pengfei Group created the hydrogen energy industry chain**

Pengfei Group is a large coal, coke, chemical and energy enterprise in Shanxi Province. It is a coal production base with production capacity of 30 million tons and a coke production base with production capacity of 5 million tons. It is also the only private enterprise in Shanxi Province that is among the top 100 of China's Top 500 Private Energy Enterprises. Based on its foundation in the coal-coke chemical industry, Pengfei Group has created a modern hydrogen energy industry chain consisting of four processes of "hydrogen production, transportation, refueling and utilization". In 2022, Pengfei Group's first hydrogen energy project – which uses coke oven gas to produce high-purity hydrogen- was officially put into production. It has adopted different methods to produce green hydrogen other than the original gray hydrogen and has planned to gradually develop waste heat recovery based coke dry quenching power generation projects to produce green hydrogen. In terms of hydrogen refueling, Pengfei Group has successfully built four comprehensive hydrogen refueling islands in 2023. These comprehensive energy islands integrate comprehensive functions such as hydrogen refueling, oil refueling, CNG, and charging as well as non-oil services. Hydrogen refueling will be carried out through four hydrogen refueling machines with a daily refueling volume of 2,000 kilograms, which will provide "one-stop" and "all-round" energy supply for various vehicles (The People's Government of Xiaoyi City, 2023). In terms of hydrogen utilization, Pengfei Group manufactured and put into use the first batch of 100 hydrogen heavy-duty trucks in 2022. In 2023, it successively put into use three hydrogen commuter buses, one hydrogen loader, and one hydrogen minibus, and five hydrogen buses in Xiaoyi City. So far, the first batch of heavy-duty trucks of Pengfei Group has recorded mileage of more than 8 million kilometers, with carbon emissions reduced by 11,000 tons and air purified amounting to 160 million cubic meters (Xinhua News Agency, 2024). Pengfei Group has made plans for building 24 hydrogenation energy islands in Shanxi Province, four of which have been officially put into use, with daily hydrogenation capacity of up to 10 tons (Solarbe, 2023). In December 2023, Pengfei Group was awarded the title of "Chain Leader" of the Hydrogen Energy Industry Chain by the People's Government of Shanxi Province (Pengfei Group, 2024).

5.3. Transition at the Society Level

Public engagement and benefits in energy transition and low-carbon development.

Shanxi actively promotes the development of new energy to support rural revitalization and improve rural lives. By May 2021, Shanxi Province has built and connected to the grid 5,532 photovoltaic poverty-alleviation power plants, which brings more than CNY 1.8 billion of revenue from power generation each year and drives an average annual increase of CNY 200,000 in income for collective economies of 9,963 villages. As of the end of 2020, the photovoltaic poverty alleviation power plants in Shanxi Province have recorded total revenue of CNY 3.736 billion from power generation, benefiting more than 720,000 poor families. In addition, Shanxi Province is actively carrying out various strategies in the field of low-carbon transport, vigorously promoting new energy buses and taxis, strengthening the construction of charging infrastructure, and creating an efficient green and low-carbon transport system. By the end of 2023, there have been 14,900 new energy buses in Shanxi, accounting for 94.2% of the total number of the province and 24,800 new energy taxis, accounting for 59.8% of the province's total. It is expected that by the end of 2025, the total number of charging piles in the province's highway service areas will reach 1,349 and that of parking space with charging guns will reach 2,562 (Department of Transportation of Shanxi Province, 2023).

Case 7 **Zhuangshang Village in Ruicheng County, Yuncheng City built the first "zero-carbon demonstration village" in China**

The PEDF technology refers to a power distribution system applied in the building industry using four technologies of solar photovoltaics, energy storage, direct current distribution, and flexible power utilization. It can effectively generate renewable energy through photovoltaics and is an important pillar for the development of zero-carbon energy. In 2019, with the support of Academician Jiang Yi's team, Nanjing Guochen company made a demonstration on the PEDF technology for 27 households and a cave cultural tourism area in Zhuangshang Village, Ruicheng County, Yuncheng City, in Shanxi Province. In August 2021, under the support and leadership of the Party Committee and the People's Government of Ruicheng County, the commercial project of the new rural PEDF power distribution system in Zhuangshang Village, jointly constructed by China Power Investment Corporation, a subsidiary of the State Power Investment Corporation, and the State Grid Shanxi Company, was officially launched, using the PEDF technology to develop and construct distributed photovoltaics in the county. At the first phase of the project, a PEDF system was built in Wang Qiao Hometown Cultural Tourism Scenic Area in Zhuangshang Village, covering 16 households and more than 40 cave dwellings in 11 courtyards with an installed capacity of 250kW. Two-direction charging piles and zero-carbon charging stations for photovoltaic carports, electric vehicles and electric tricycles were also built in the first phase. At the second phase of the project, application scenarios of photovoltaic courtyards and photovoltaic corridors were built and a 2MW commercial PEDF system was constructed on the roofs of 71 households and on wasteland (Shanxi Daily, 2024). The project was successfully connected to the grid in early 2022 and established a new power system of "rooftop photovoltaics + energy storage + direct current distribution + flexible power utilization". It is estimated that having been connected to the grid at full capacity, the project can help to save 800 tons of standard coal, 7,700 tons of water, and reduce carbon dioxide emissions by 2,450 tons and smoke emissions by 4.46 tons each year. In April 2023, Zhuangshang Village was awarded the title of China's Zero-carbon Energy Demonstration Village jointly by the United Nations Development Program (UNDP), the Global Environment Fund (GEF), and the Ministry of Agriculture and Rural Affairs of China. In December 2023, Zhuangshang Village's new PEDF distribution system won the Energy Transition Changer award at the COP28, becoming one of the 28 selected projects worldwide and one of the five selected projects in China (The People's Government of Yuncheng City, 2023). Currently, the third phase of the PEDF project in the village is under planning, and it is planned to achieve whole village coverage by 2027.

06 CHALLENGES AND THE ROAD AHEAD

6.1 Energy Challenges

Low energy efficiency. In recent years, Shanxi Province has kept promoting energy-saving transformation in key industries and achieved declining energy intensity across the province. In the first three years of the 14th Five-Year Plan, the energy intensity of Shanxi Province decreased by about 10.9%, exceeding the scheduled progress by 1.9 percentage points. It has completed 73.7% (China Energy News, 2023) of the total energy saving goal outlined in China's 14th Five-Year Plan. However, in absolute terms, the energy intensity of Shanxi Province is still significantly higher than, in fact twice as much as, the national average[14]. With the continuous advancement of energy conservation, the province's energy-saving space became narrow. In some high-energy-consuming industries, there are more low-tech processing and primary products but much fewer high-value-added products, making it more difficult to improve energy efficiency.

Limited space for large-scale development of renewable energy. Over 80% of Shanxi's landscape is mountainous areas. The limited plain areas are almost entirely covered by farmland. Therefore, there is very limited land suitable for the development and construction of renewable energy projects. Renewable energy in Shanxi Province developed rapidly during 2015 and 2023, witnessing a significant increase in the installed capacity and power generation of wind power and photovoltaic power. However, with the intensive development and rapid implementation of wind power and photovoltaic projects, land constraints for future large-scale development are becoming gradually prominent. Besides, due to factors such as lack of energy storage and power grid construction, the small increase in transmission capacity of external transmission channels, and the limited consumption ability in the local market, there is insufficient space to develop and consume new energy.

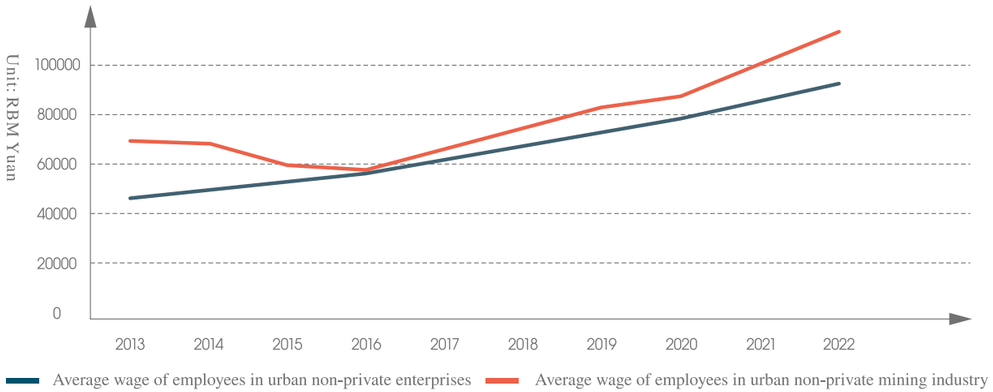
A balanced approach in low-carbon energy transition to ensure both high quality energy development and energy security. Shanxi shoulders the important political responsibility of ensuring energy security for the country. In light of the Carbon Dioxide Peaking and Carbon Neutrality goals, the province also undertakes multiple objectives and tasks such as energy security, pollution reduction, and carbon emission reduction in addition to economic growth. As clean energy has not yet formed a secure and reliable alternative solution while the traditional energy is gradually withdrawing from the market, coal energy remains the "ballast stone" to ensure energy security, and it is necessary to effectively balance the security and low-carbon benefits of the energy system.

6.2 Social Challenges

The coal industry involves a big population. The employees in the industry are often equipped with very limited skills, thus creating great re-employment pressure. Due to the pressure from both accelerated decline in coal production and increased producing efficiency, employment decline in the coal mining and dressing industry of Shanxi Province has accelerated. By 2060, the employment of the coal mining and dressing industry will shrink to 12,000-187,000 people, which means 17,000-24,000 people to be laid off per year from 2023 to 2060. Since the coal workers in Shanxi are mainly elder men with low education level and limited skills, it is difficult for them to get employed in strategic emerging industries. What's more, new industries also have difficulties in employing coal workers in the region. The wage of the mining industry, in general, still ranks high among various industries in the region, and the coal industry is mostly owned by state-owned enterprises. It is therefore difficult for coal workers to find jobs with the same packages, resulting in low incentive for transition.

⑭ Calculated according to data on GDP and energy consumption of the whole country and Shanxi Province.

Figure 6-1 Average wages of employees in urban non-private mining and non-mining enterprises 2013-2021
For a long time, the average wage of employees in the urban non-private enterprises in the mining industry has been generally higher than that in non-mining industries, which makes the employees in the mining industry less motivated to switch to other industries.
Sources: Shanxi Statistical Yearbooks



Women and young people in coal mining areas will be the most vulnerable groups. The number of female employees in Shanxi's coal industry is relatively small, but most of them are working in supporting positions such as logistics, which are very likely to be shed. Female workers earn far less than male workers on the front line of coal production, they are more likely to be laid off under the coal reduction policies. In addition, decarbonization is a long-term process, and the unemployment risk in the coal industry will rise with the progress of carbon neutralization. Current young workers in the coal industry are more likely to lose jobs in the future.

No stakeholder participation mechanism has yet been established. Energy transition is still mainly driven by top-down policy promotion, with bottom-up public participation. Just transition involves multiple stakeholders including coal workers, enterprises, communities, financial institutions, local governments and the central government. In the context of Carbon Dioxide Peaking and Carbon Neutrality, to promote the orderly and stable transition in the coal mining regions, it is necessary to establish a dialogue mechanism for stakeholders to participate as soon as possible. Transition should be carried out from bottom up at the society level to stimulate the motivation of coal workers, enterprises and regions. Public awareness and expectations should be elevated to jointly formulate strategies and policies for just transition recognized by all stakeholders.

6.3 Technological Challenges

Lack of technological innovation capabilities will hamper the development and application of low-carbon technologies. Shanxi has rich experience in technological innovation in such fields as energy and heavy industry. However, it is still far behind in research and development of advanced low-carbon technologies in new energy, energy conservation and environmental protection, carbon capture and utilization. Lacking core industry-leading technologies, scientific research institutions and high-tech enterprises in Shanxi need to improve their innovation capabilities.

There are barriers to the promotion of low-carbon technologies, and it is difficult for advanced technologies to get applied. Although Shanxi Province has made some progress in clean energy, energy conservation and emission reduction over the years, it is still facing many difficulties in promoting and applying low-carbon technologies. Some enterprises are not ready to accept new technologies and processes and are concerned about technical risks and investment costs. Besides, insufficient policy support and absence of a market promotion mechanism have restricted the rapid popularization of low-carbon technologies.

Shortage of technical staff makes it difficult to meet the need for professionals. As energy transition goes deep, Shanxi has an increasingly urgent demand for technical staff. However, it does not have a talent pool of professionals, especially high caliber technicians. Besides, the professional training and introduction mechanism is not well developed, resulting in a big loss of technical professionals, which in turn leads to the failure of meeting the need for professionals.

6.4 Economic Challenges

As fiscal support for coal-based economies is declining, the impetus for transition is likely to weaken. Public finances have always been an important support for promoting regional transformation and upgrading, and have played an irreplaceable role in guiding and promoting emerging industries. However, as traditional industries in coal-producing areas weaken, the coal industry, as one of the important sources of regional finance, will be greatly impacted[⑮]. As estimated by the Research on Just Transition of Shanxi's Coal Industry under the Targets of Carbon Dioxide Peaking and Carbon Neutrality – A Special Report on the Coal Mining and Dressing Industry (Issue 1), coal tax revenue will continue to rise in the short term, with a slight increase to be expected in the medium term. Taking 2006 as the base year to eliminate the impact of inflation rate, the tax revenue of the coal mining industry will continue to rise in both the baseline and the stronger policy scenarios from 2023 to 2030, but the growth rate of coal tax revenue will decline significantly. The average annual growth rate in the baseline scenario will drop significantly from 17.17% during the 14th Five-Year Plan period to 11.55% during the 15th Five-Year Plan period; and the average annual growth rate in the strengthening scenario will drop from 15.72% during the 14th Five-Year Plan period to 8.87% during the 15th Five-Year Plan period. Therefore, if Shanxi Province fails to successfully guide the development of new industries to replace the coal industry in the region before 2030, the development of alternative industries will face more difficulties and challenges, made worse by falling fiscal funds for industries.

	2023	2024	2025	2026	2027	2028	2029	2030
Tax revenue from every 10,000 tons of coal (CNY 1 million)	134.1	152.5	173.4	197.2	224.2	254.9	289.8	329.5
Baseline policy scenario (CNY 1 billion)	1170.6	1355.3	1569.2	1816.8	2103.4	2435.3	2764.0	3137.4
Strengthening policy scenario (CNY 1 billion)	1168.6	1312.5	1474.1	1655.6	1859.5	2088.4	2299.3	2531.7

Table 6-1 Estimated tax revenue of the coal mining and dressing industry in different scenarios
Note: Taxes are calculated based on the prices in 2006, without taking into account the impact of inflation.

Not all the profits from coal production can be used to support the development of coal-producing regions. The profits and wealth generated by coal production do not all remain in the coal-producing regions; much of the revenue often flows to asset owners who are not necessarily local. In addition, private coal enterprise owners may invest their assets in more promising industries in other provinces. Therefore, how to retain the large amount of private capital generated by the coal industry, guide Shanxi-based coal entrepreneurs to participate in major regional infrastructure construction and development of potential non-coal industries, and promote coal entrepreneurs to continue to invest locally and contribute to regional transformation and development are what the coal-producing regions need to focus on in the future.

⑮ Using the scenario analysis method, the tax revenue of the coal mining and processing industry is predicted by calculating the estimated coal production and unit coal tax level, that is: the estimated total tax revenue of the coal mining and processing industry = the estimated coal production × the estimated unit coal tax revenue.

6.5 Financial Challenges

Regional transition is still in short of funds, and the market-based social capital attraction mechanism is not yet established. To ensure just transition in coal-producing areas like Shanxi Province, sufficient funds are required for resettlement of the affected population, development of new industries, and ecological restoration. It is predicted that a total of CNY 41.455 billion to CNY 51.268 billion of fiscal funds will be needed for employee placement under different scenarios by 2060, based on the prices in 2022.

Coal enterprises are still the main source of funding, supplemented by fiscal funds. Due to the lack of market-based incentive mechanisms, social capital shows little intention to participate in just transition. Funding sources for just transition of the coal mining and dressing industry in Shanxi Province involve multiple players such as the government, enterprises, and social investors. The transition mainly relies on enterprise investment and fiscal revenue. Efforts are being made to explore more financial instruments such as bonds, insurance and fund to encourage social capital to participate in the transition. Currently, other than investment by enterprises, funding for Shanxi's just transition is mainly from fiscal revenue. There is little contribution of social capital from the market. From previous sections, it can be concluded that the profitability of coal mining and dressing enterprises fluctuates greatly along the changes in the coal market. The development prospects of the coal industry is dimmed by energy transition. As a result, the profitability of coal enterprises also faces uncertainty. It is difficult to mobilize sufficient internal funds to support just transition. The progress of just transition is closely linked to the fiscal revenue and expenditure of local governments. Given that the coal mining industry contributes a large amount in the fiscal revenue of Shanxi Province, the fragile transition progress will be further exacerbated.

Funds are not integrated and there is a lack of evaluation measures. Since funds for just transition are from different departments, lack of coordination measures in current policy framework makes it difficult to integrate the funds in different links and sectors. Sometimes, the amount of funding withdrawn from the mine environmental governance fund does not match needs of restoration among different mines in the same mining group. The lack of coordination policies to guide fund between coal mines poses a challenge for coal mines with higher needs for restoration funds but limited quota. In addition, there is no effective measures in the existing policies to evaluate the effectiveness of capital investment. In the face of limited fiscal funds and limited conditions during the window of transition, dynamic adjustment of how and where to invest based on evaluations will help enhance the effectiveness of funds in supporting just transition.

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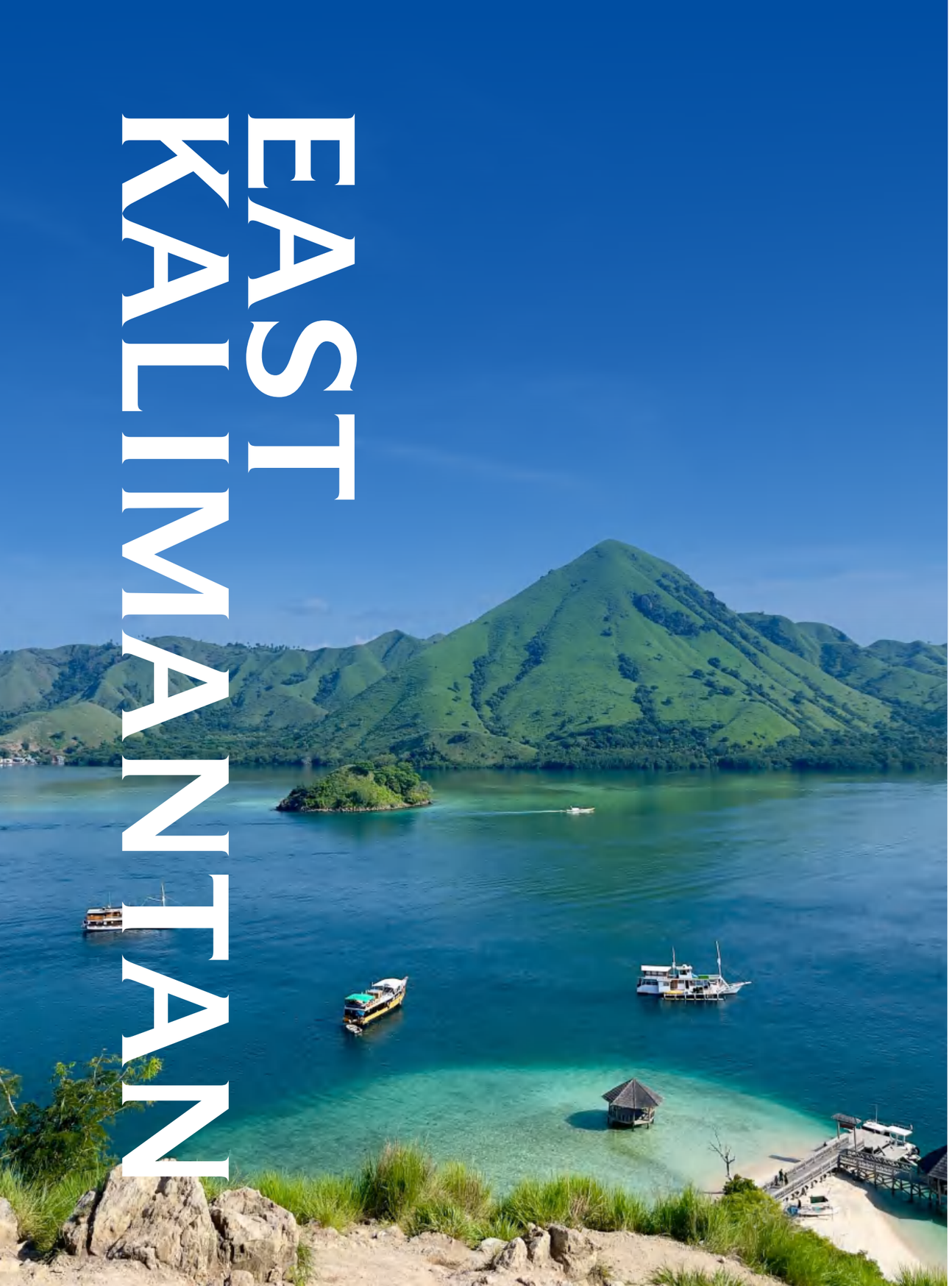


TRANSITION AWAY FROM COAL: THE CASE OF EAST KALIMANTAN

01 EAST KALIMANTAN PROVINCE PROFILE

Figure 1. Indonesia and East Kalimantan Province
Source: Wikipedia

East Kalimantan province is Indonesia's largest coal producing region located in Kalimantan Island. There are two prominent cities in the province, Samarinda capital city and Balikpapan, a regional hub historically linked with oil and gas development. With a total area of 127,000 km^2, East Kalimantan is the third largest province in the island by area after Central and West Kalimantan (Badan Pusat Statistik Kalimantan Timur, 2023). The province is divided into seven sub-provincial regencies, namely Berau, West Kutai, Kutai Kartanegara, East Kutai, Mahakam Ulu, Paser, Penajam Paser Utara Regencies.

With 3.9 million population in 2022 and an average annual population growth of around 2%, most of East Kalimantan's population resides in Samarinda, with a share of 21%. This is followed by Kutai Kartanegara regency and Balikpapan. The majority of the population is working in wholesale & retail, agriculture and forestry. There are 1.85 million people classified as workforce with 94% employment rate, based on official figures. Among the workforce 44% are high school graduates and 15% are university graduates (Badan Pusat Statistik Kalimantan Timur, 2023).

The three aforementioned sectors dominate the employment with each accounting for roughly 20% of total jobs, while 'mining and quarrying' accounts for roughly 8.6% total jobs[1]. This mining employment figure far exceed other coal dependent regions such as Mpumalanga province in South Africa (8%) or Jharkhand and Chhattisgarh in India (1-2%), further emphasizing East Kalimantan's strong dependence on coal (International Energy Agency, 2022).

In the 4th quarter of 2023, the East Kalimantan's economy grew by 5.76% (Year-over-Year). The province exhibited the second highest growth rate in the Kalimantan region and higher than the national economic growth of 5.03% YoY. The mining and quarrying sector contributed 3.31% YoY to the growth in line with the elevated coal production. The construction sector has also contributed notably toward the economic growth with 1.06% YoY. The growth in this sector is in parallel with the development of Indonesia's new Nusantara Capital City (Ibu Kota Negara, IKN) located in the province and the development of an oil refinery project in Balikpapan (Bank Indonesia, 2024)

The New Capital City: Nusantara IKN

The new Nusantara Capital City (IKN) is currently being built in Penajam Paser Utara Regency. It is planned to host the central government while Jakarta remains as the center of economy. According to Minister of Public Work and Housing, per February 2024, the first development phase progress has reached 74%, focused on the construction of presidential palace and offices, minister's house, government employee house, coordinating ministry office, and toll road. The government expects the new capital will bring an additional 2 million people gradually until 2045.

[1] The 'mining and quarrying' sector comprises various mining activities. Between 2018 to 2022, coal and lignite mining constituted roughly 80% of total mining and quarrying economic activities in East Kalimantan. 'Coal' refers to both coal and lignite throughout this paper.

02 COAL DEPENDENCE IN EAST KALIMANTAN PROVINCE

2.1 Overview of the coal sector

Indonesia's abundant coal reserves are concentrated primarily in the islands of Sumatra and Kalimantan. In 2020, the two largest surface coal proven reserves were in the province of East Kalimantan and South Sumatera, 9.7 bn tonne and 4.4 bn tonne, respectively (Figure 3). East Kalimantan's surface coal proven reserve comprised roughly 46% of Indonesia's coal reserves. The province's coal is largely categorized as surface coal, located at a depth between 0-100 meters or those which could be mined through open pit mining. Smaller underground coal proven reserves of 16.9 mi tonne are also present (Kementrian Energi dan Sumber Daya Mineral, 2021).

In 2021, coal production in East Kalimantan reached 294 million tonnes (BPS Provinsi Kalimantan Timur, 2023). This figure represents the last official figures published by the national statistics. Coal demand is driven by the high export demand while also supported by domestic use.

East Kalimantan's coal production is dominated by private companies, large and small. As a major stakeholder in East Kalimantan, their actions will be detrimental to the the province's future economy. Nearly all of the coal miners are still focused on maximizing their coal production. Some, however, have shown indication to diversify their business as we will explore in latter sections. Listed below are some of the largest coal mining companies in East Kalimantan.

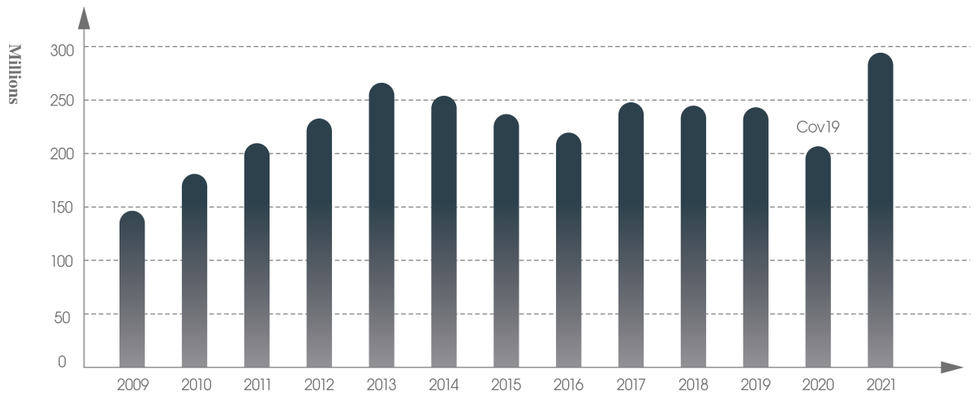


Figure 2. East Kalimantan Coal Production Source: (Badan Pusat Statistik, 2022)

Company	Details	Production
PT Kaltim Prima Coal. A subsidiary of Bumi Resources Tbk	Located in East Kutai regency. More than 61,000 hectares, 4,500 employees and 21,000 contractor personnel	53 mi tonne in 2023, 9% increase from 2022 (49mi tonne)
PT Berau Coal Energy Tbk	Located in Berau regency. More than 100,000 hectares	27.5 mi tonne in 2022, 2% decrease from 2021 (28mi tonne)
PT Kideco Agung Jaya. A subsidiary of Indika Energy	Located in Paser regency. More than 47,000 hectares	30 mi tonne in 2023, 14% decrease from 2022 (35mi tonne)

Table 1. East Kalimantan Largest Coal Miners
Source: (PT Bumi Resources Tbk, 2024) (Indika Energy, 2024) (PT Berau Coal Energy Tbk, 2023)

As the largest coal producer province, coal mining concessions in East Kalimantan span over 9.3 million hectares, 73% of East Kalimantan's total area (Bachruddin & Saraswati, 2021). These are largely spread out across Samarinda, East Kutai, West Kutai, Paser, Berau, Mahakam Ulu, and Kutai Kartanegara. The largest coal mine in East Kalimantan is located in Sangatta, East Kutai regency with operated by PT Kaltim Prima Coal, one of the largest coal mining companies in Indonesia. Beyond the large coal mining companies, the presence of smaller mining operations is also notable.

Figure 3. Indonesia Surface Coal Resources by Province Source: (Kementrian Energi dan Sumber Daya Mineral, 2021)

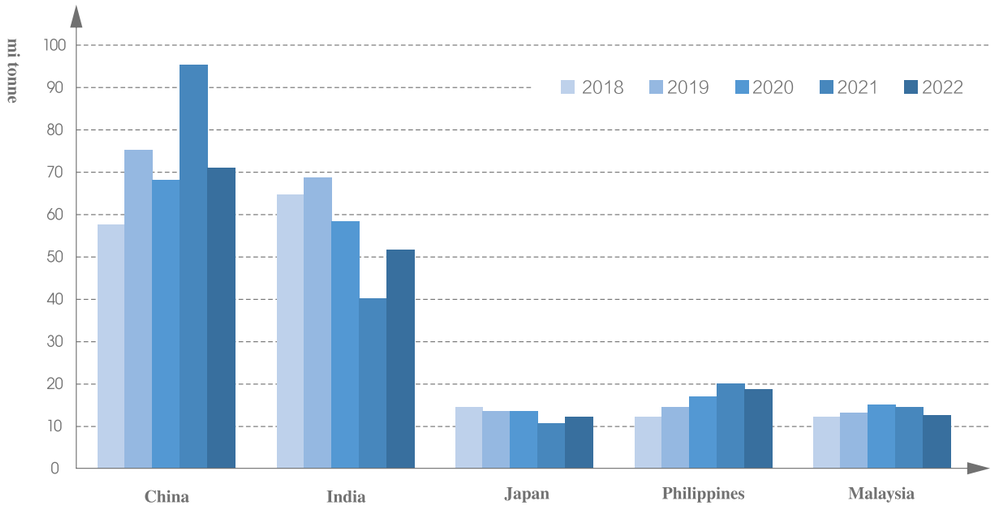
2.2 Export Markets

It is important to note that Indonesia's coal sector is largely export-facing. China and India comprised the largest export market for East Kalimantan's coal (Figure 4). In 2021 its coal exports reached 235 mi tonne, with 95.5 mi tonne (40%) headed to China and 40.3 mi tonne exported to India. The next largest export markets are Japan, Philippines, and Malaysia (Intoniswan, 2024).

In 2021, East Kalimantan's coal destined for export was four times larger than for Indonesia's domestic use, a trend somewhat similarly exhibited at the national level. Indonesia's coal industry rose significantly in the 2000s which also coincided with China's rising coal demand. The significant reliance on export market exposes East Kalimantan's coal industry -and by extension its economy- to the market dynamics in the destination markets.

With the accelerating pace of energy transition in its key export markets, East Kalimantan need to plan its future well in advance. The increasing global scrutiny on coal use and commitments toward decarbonization have accelerated the adoption of Renewable Energy (RE) globally. China's pledge to achieve peak emissions before 2030 and carbon neutrality by 2060 further raises the stakes. All these, taken together, indicate a clear direction of travel and raises the urgency for East Kalimantan to transition from coal, as we will explore in later sections.

Figure 4. East Kalimantan Coal Export Destinations Source: (Intoniswan, 2024)



2.3 Coal for electricity

In the electricity sector, Coal-Fired Power Plants (CFPP, PLTU) dominate East Kalimantan's electricity generation with an installed capacity of 703 MW out of the 1,064 MW total (Table 2). Within the power grid operated by PLN state utility company, there is only one additional CFPP planned, PLTU Tanah Grogot as listed in the Electricity Supply Business Plan (Rencana Usaha Penyediaan Tenaga Listrik, RUPTL) (PT PLN (Persero), 2021). Given the province's outsized coal production, East Kalimantan's own coal consumption is small relative to the national use. The province total CFPP capacity account for roughly 3% of the national capacity (Kementrian Energi dan Sumber Daya Mineral, 2021) (Just Energy Transition Partnership Indonesia, 2023)

Name	Capacity	Status
PLTU Tanjung Redep	2 x 7 MW	Existing
PLTU Kaltim (FTP2)	2 x 100 MW	Existing
PLTU Kaltim (MT)	55 MW	Existing
PLTU Kaltim/Teluk Balikpapan (FTP1)	2 x 110 MW	Existing
PLTU Kaltim 4	2 x 100 MW	Existing
PLTU Tanah Grogot	2 x 7 MW	Planned

Table 2. East Kalimantan CFPP in PLN power grid in RUPTL 2021-2030
Source: (PT PLN (Persero), 2021)

2.4 Economic impact of coal.

The impact of the coal sector on the local economy is significant. Table 3 compares East Kalimantan with a number of coal dependent province. With coal mining reaching 35% of the provincial GDP, East Kalimantan economy is much less diversified than other provinces. The trend is similarly reflected in the concentration of workers.

Global Energy Monitor estimated that the province holds nearly 40% of Indonesia's total coal mining employment. Estimates for Indonesia's total coal mining employment, however, vary widely from 159,900 (Global Energy Monitor, 2023) to 250,000 (Institute for Essential Services Reform, 2022). The overall impact of the coal mining sector would likely extend beyond such figures, through indirect and induced employment to support the industry activities.

	South Kalimantan	Central Kalimantan	East Kalimantan	North Kalimantan	South Sumatera
Coal mining share in provincial GDP	17.2%	7.3%	35.1%	17.8%	6.1%
Coal share in provincial goods export	78.1%	58.0%	75.6%	74.2%	18.9%
Mining and quarrying share in provincial employment	3.9%	6.0%	8.6%	3.6%	1.6%
Credit to mining and quarrying as share total non-financial bank credit	5.0%	0.1%	3.4%	n. a.	0.4%
Estimated mining and quarrying share in total provinciallabourincome	3.5%	7.0%	7.5%	3.8%	1.5%

Table 3. Key Economic Indicators in Coal Producing Provinces in 2020-21 Source: (International Energy Agency, 2022)
Note. Labour income share is calculated as average wages in each sector weighted by its share in total employment. It includes informal employment and in-kind incomes.

2.5 Coal Down-streaming

In addition to the conventional coal business, the Indonesian government aims to expand coal utilization through 'downstreaming' process. Various down streaming initiatives have been explored to convert coal into other derivative products such as methanol and Dimethyl Ether (DME) to replace cooking gas.

Based on the central government's Coal Utilization and Development Roadmap, East Kalimantan was selected to implement a pilot project for coal gasification into methanol (Kementrian Energi dan Sumber Daya Mineral, 2021). The US$ 2bn project was initially planned to be commissioned by 2024. PT Kaltim Prima Coal as the mine owner was to supply the coal to the processing facilities owned by US-based supplier Air Products and Chemicals, Inc., PT Bakrie Capital Indonesia, and PT Ithaca Resources. However, in 2023, Air Products and Chemicals, Inc. withdrew from the project. According to Indonesia's Chamber of Commerce, the coal downstreaming projects are still experiencing many obstacles due to lack of certainty on the off-taker side (Rahayu, 2023). This is expected given that the economics of coal downstreaming can be challenging (Institute for Energy Economics and Financial Analysis, 2020)

Despite strong political commitment in providing incentives such as coal royalty reduction and special coal price for feedstock, as of 2023, nearly all of the downstreaming project plans in East Kalimantan remained in assessment stage, signifying the significant challenges to proceed in their investment activities.

There are no publicly estimated figures for additional employment related to the downstreaming projects in East Kalimantan. However, similar downstreaming project plan for DME in South Sumatera with 6 mi tonne of annual coal feedstock was expected to generate around 12,000 new jobs (Kementrian Sekretariat Negara, 2022).

Table 4. Coal Downstreaming Plans in East Kalimantan Source:(Tekmira, 2023)

Project	Companies	Coal feedstock plan (annual)	Status
Coal to Methanol	KPC & KNC	6.5 million tonne	Assessment/preparation
Coal to Methanol	Kendilo Coal Indonesia	675,000 tonne	Assessment/preparation
Coal to Methanol/DME	Berau Coal	-	Assessment/preparation
Underground coal gasification	Kideco Jaya Agung	566,000 tonne	Assessment/preparation
Semi Coke	Multi Harapan Utama	1 mi tonne	Assessment/preparation

03 IMPACTS OF COAL ON LOCAL SUSTAINABLE DEVELOPMENT

Since the industrialization age coal has been dominating the global energy mix and contributed toward the global economic development. Its use, however, has also come with significant adverse impacts, particularly to the environment and public health. These adverse impacts emerge throughout the coal supply chain, from coal mining, processing and transportation, its final use, and waste disposal activities (Dai, Dong, Yan, & Xu, 2017). A number of these impacts are presented below along with case examples in East Kalimantan.

3.1 Emissions and The Climate Crisis

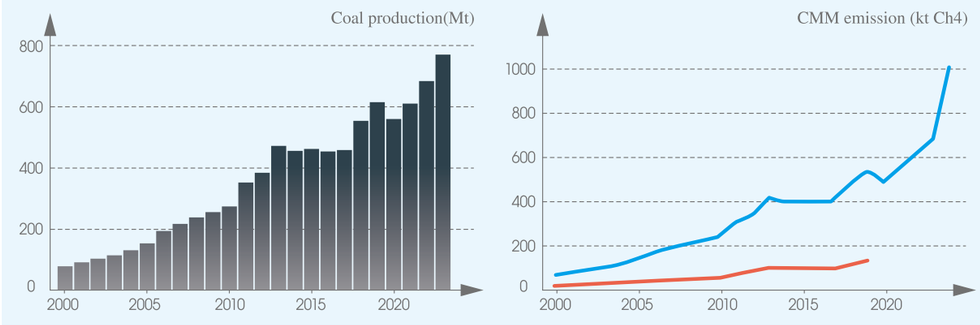
In 2021, the global energy sector contributed more GHG emissions than any other sectors. According to IEA (2023) coal was the largest emission source related to fuel combustion. According to Lindsey (2020), the average CO2 concentration at the earth's surface in 2019 is higher than at any point in time during the past 800,000 years. Additionally, coal mines also release methane (CH4) gas, another potent Green House Gas (GHG) which can be eighty times more powerful than CO2 emissions in the near-term.

In a recent study by Ember (2024), coal mine methane emissions in Indonesia have increased by 12% annually from 2000 to 2019. This figure was estimated to be up to eight times higher than the latest official estimates. There is no disaggregated figure for East Kalimantan, but the province's share in the total methane emissions is likely significant given its large share on Indonesia's coal production.

There are various factors which contribute to the global temperature increase, including land-use changes such as land clearing for mining activities. East Kalimantan experienced the highest increase in surface air temperature in 2023. The rate of increase in surface air temperature recorded at the Temindung Meteorological Station, Samarinda reached a high point of 0.47 degrees Celsius per decade, a figure which was higher than the global average increase (Arif, 2023)

Other notable weather conditions have also been noted. Rainfall pattern in regions such as Berau regency has become more sudden and shorter or alternatively, falls very heavily and accompanied by strong winds. The changes in weather pattern have forced local farmers to adapt by adjusting their working hours to begin earlier morning or later in the evening to avoid working during the day under extreme heat (Arif, 2023).

Figure 5. Indonesia's Rising Coal Output and Coal Mine Methane Emissions Source: (Ember, 2024)



3.2 Air Quality and Dust from Coal Mines

Nearly all activities within the coal value chain from coal mine to its final use produce significant amount of dust and hazardous air pollutants which pose serious risks to the health and environment. Dust generated during mining activities has been linked to several pulmonary diseases such as black lung disease, silicosis, and Chronic Obstructive Pulmonary Diseases (Finkelman, Wolfe, & Hendryx, 2021).

IESR's (2023) coal industry study in the Paser regency revealed that the effect of dust coming from coal mining site is notable as it gets carried by the wind to the nearby population. Coal mining companies do have mitigation actions such as watering the roads on a weekly basis, but the dust issue, as reported by the nearby population, persists.

3.3 Abandoned Open-pit Mines

Figure 6. Abandoned Open-Pit Mines in East Kalimantan

In 2020 there were more than 1,400 mining business permits (IUP) issued for East Kalimantan (Dinas Energi dan Sumber Daya Mineral Kalimantan Timur, 2023). Based on Jatam's records using satellite image data in 2018, there are 3,033 abandoned open-pit mines, including coal mines, spread throughout Indonesia. Of that number, around 1,735 abandoned open-pit coal mines are located in East Kalimantan in the form of large lakes with various sizes ranging from hundreds of square meters to tens of hectares (Jaringan Advokasi Tambang, 2023) .

Based on the Department Energy and Mineral Resources of East Kalimantan's record in 2018, there were only 539 abandoned open-pit mines throughout the East Kalimantan with most located in Kutai Kartanegara Regency (264) and Samarinda (130) (Kementrian Lingkungan Hidup dan Kehutanan, 2018). Setting aside the differences between the datasets, between 2011 to 2022 forty lives have been lost due to accidents in abandoned pits in East Kalimantan Province (Lubang bekas tambang Kaltim: 40 tewas sejak 2011, didominasi anak, 2022).

Abandoned pits may also bear other health risks such as heavy metal content exceeding safe limits within the water. Laboratory test on water samples from an abandoned open pit mine in Samarinda revealed that there were heavy metal contents, such as Manganese and Iron, above the threshold specified by the Ministry of Health regulations. Such water, when consumed or used for irrigation can lead to detrimental health impacts. Ironically, the water from these abandoned open-pit mines is often used by nearby population to meet their needs for daily water and agricultural irrigation needs as prior mining activities have hampered their access to clean water, as occurred in the Makroman Village, Samarinda. Another example in Bukit Raya Vilage, Kutai Kartanegara regency showed that the nearby population use of the water may also extend to other activities such as fishery (Kementrian Lingkungan Hidup dan Kehutanan, 2018).

Unlike the more visible accidents relating to abandoned open-pit mines, negative health impacts due to the contaminated water is more difficult to be observed and reported. The Government is keeping track of the post-mining operation activities, including land reclamations, however there is a clear need for improvements.

04 THE URGENCY OF A JUST ENERGY TRANSITION IN EAST KALIMANTAN

In line with the global ambition toward mitigating the climate crisis, the Government of Indonesia has outlined a target to reduce Green House Gas emissions by 31.89% by 2030, with a conditional reduction target of 43.2%, subject to international support (Government of Indonesia, 2022). These aims are complemented by the national Renewable Energy (RE) share target of 23% by 2025, albeit the realization of RE share still stood at 13% as of 2023, with coal holding a sizeable 40% share of the national energy consumption (Kementrian Energi dan Sumber Daya Mineral, 2024).

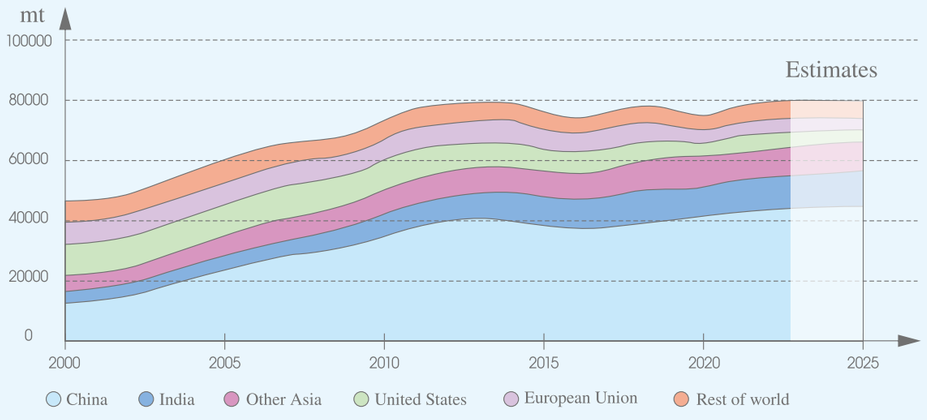
The global and national commitments increase the pressure transition away from coal. Considering East Kalimantan's strong dependence on the coal industry, the following section further elaborate the urgency for the province to plan its future beyond coal and to start early in charting its pathways.

4.1 Rising Global Scrutiny on Coal Use and Declining Renewables Cost

Globally, there has been rising scrutiny on the coal industry and coal-related investments across various part of the value chain. In COP26 event in 2021, more than 40 countries pledged to phased out coal. Since then, a number of other initiatives have been rolled out globally, including the Just Energy Transition Partnership which aim to assist several coal-reliant countries -including Indonesia- to phase out coal.

In the pursuit of the collective global ambition to reach 'peak emission' various scenarios have outlined the potential of coal demand to peak in the coming years. Global coal use has practically been plateauing in recent decade, with declining use in developed markets albeit compensated by the rise in emerging markets. Recent IEA Coal report in 2023 forecasted global coal demand to continue plateau and decrease within this decade (International Energy Agency, 2023).

Figure 7. Global Coal Consumption Near Term Outlook Source: (IEA, 2023b)



Future projections and renewables competition. Projections do have a wide degree of uncertainty. The invasion on Ukraine, as reported by Reuters, has which shifted coal trade activities from Russia and caused temporary global spike in coal price (Varadhan, 2023). The disruption revealed that the coal transition and the rebalancing of global supply and demand is unlikely to be a smooth ride. In 2023 Indonesia's coal production reached a peak of 775 mi tonne coal rising from 685 mi tonne a year earlier (Kementrian Energi dan Sumber Daya Mineral, 2024).

Such transition, nevertheless, remain inevitable driven by the accelerating pace of global capital allocation to clean energy, overshadowing investments in fossil fuel. The decline of renewable energy costs has spurred massive investments in the renewables in both China and India, East Kalimantan's primary coal export markets. China, with its 1,500 GW of installed renewables capacity, led the world in 2023 by a significant margin while India's nearly 180 GW capacity placed it in the global top four (Ember, 2024).

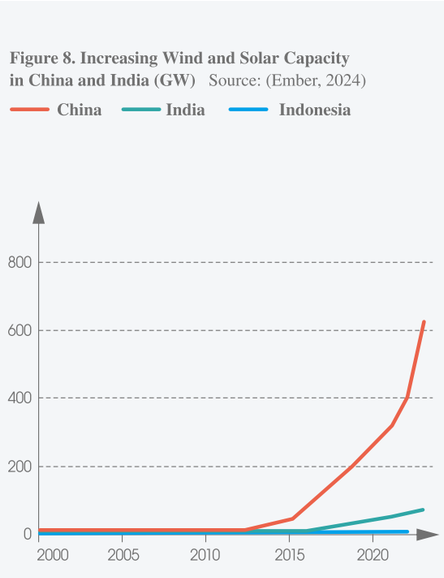
China's 2030 Target. China has outlined an ambitious target for clean energy adoption and is currently the world's leader in solar and wind deployment. In 2020, during the UN Climate Ambition Summit, President Xi Jinping outlined a goal to reach 1,200 GW of wind and solar installed capacity by 2030. The country looks set to reach their capacity target much sooner in 2024 or 2025, from practically near zero two decades ago (Afry, 2023).

Clean energy investments are now crucial element for China's development and the country sees the transition as an opportunity, not solely as a threat to their existing coal industry. It is a viewpoint which other regions can learn from. While China's coal consumption remains robust, the pace of renewables adoption meant that the peaking of coal demand is inevitable.

In sync with China's ambition in clean energy, India has outlined a 500 GW of renewable energy capacity target by 2030. In 2023, India has installed roughly 18 GW of RE capacity, bringing the cumulative capacity to about 190 GW as of the first quarter of 2024 (Institute for Energy Economics and Financial Analysis, 2024). The country is also home to the Bhadla Solar Park, one of the largest solar PV power plants in the world with 2.2 GW of capacity, a testament to India's commitment in growing its renewables capacity (Bello, 2021).

Renewable energy presents a direct competition for coal use in power generation thus it is important for East Kalimantan stakeholders to look ahead beyond the near-term coal demand trends and to anticipate the leading indicators of renewables adoption in both countries.

Figure 8. Increasing Wind and Solar Capacity in China and India (GW) Source: (Ember, 2024)



4.2 Increasing Restriction for Financing for Coal Mines

Retreat of financing in coal-related sector have also been notable with more than 200 globally-significant financial institutions outlined their coal exclusion policies (Institute for Energy Economics and Financial Analysis, 2023). More than 50 financial institutions in Asia-Pacific have joined in.

With the ever-rising scrutiny on the coal sector, coal miners will likely continue to face significant challenges to fund their long-term business activities, especially for expansion of new coal mines. In 2022, despite the increasing profits of coal companies related to the coal supply crunch induced by Ukraine invasion, coal exclusion momentum by financiers remains strong which suggests that the appetite for coal projects have likely changed for good.

4.3 East Kalimantan Coal Reserves

Assuming that coal production is held constant at 294 mi tonne annually and based on the latest 2020 data of 9.7bn tonnes of surface coal proven reserves, without any further expansion the coal reserves can be exhausted in around 33 years. This, on paper, aligns quite well with President Joko Widodo's pledge at the 2023 Hannover Messe in Germany, that all Indonesian CFPP would be closed by 2050.

Such figures, however, require nuanced understanding as coal exploration and mine expansion activities will likely still take place albeit with a limited speed. The different grades of coal with varying calorific values also introduces additional complexity in forecasting future market situation.

Nevertheless, the rapid acceleration in East Kalimantan's coal extraction coupled with global restriction in obtaining financing for coal project meant that the province will need to thoughtfully consider its coal sector outlook, as its expansion is heading into the opposite direction of the global trends.

Chinese leader Xi Jinping's statement in 2021 outlining the intent for China to stop building new coal-fired projects abroad further emphasize the shifting global trend. Indonesia's recent coal power build out has mainly relied on Chinese financing, and China's changing position will inevitably alter the investment landscape.

Ultimately, new coal mine investments can take considerable time to reap profits. With uncertain outlook on the global coal demand, investors are cautious in expanding new production capacity which have a high risk of being 'stranded' as and when its future demand (Grantham Research Institute on Climate Change and the Environment, 2022).

Just Transition and JETP

Indonesia's Just Energy Transition Partnership (JETP) was launched in 2022 with the support of the International Partners Group co-led by the United States of America and Japan. The partnership aims to help several coal-reliant countries such as Indonesia to phase out coal and accelerate renewable energy adoption. The partnership aims to mobilize US$ 10bn of public and US$10bn of private funding.

JETP's Comprehensive Investment and Policy Plan (CIPP) outlined the roadmap toward reducing emissions and defined key investment areas such as the power grids and early coal power retirement.Several project recommendations outlined in the JETP are located in and around East Kalimantan, including an electric transmission lines to connect hydro resource in neighbouring province to support industrial development in East Kalimantan.A crucial element of the JETP is the outlining of just transition guiding principles. The partnership has also sparked various initiatives to look into the potential impacts of coal phase out to affected communities and the required actions to anticipate coal phase out.

Just transition' concept is crucial as it seeks to cast attention on the population that are most affected by the global energy transition (Grantham Reserach Institute on Climate Change and the Environment, 2024). Its importance is even higher for coal dependent regions such as East Kalimantan.

05 TRANSITION EFFORTS AND ACTIONS

The concerns on future outlook of Indonesian coal have been simmering in the background for some times. The Government of Indonesia's coal downstreaming ambitions - along with its generous incentives- further affirm the underlying anxiety that the coal export long-term outlook remains uncertain for Indonesia, just as it is for East Kalimantan.

The aim to downstream coal product aims is to secure domestic demand for coal in anticipation of global market shift, but has so far led to limited success, primarily due to economic barriers. It is important for East Kalimantan stakeholders to comprehend these fundamental challenges to navigate its future.

This section outlines several guiding directions and presents East Kalimantan's current energy transition landscape.

5.1. Planning Ahead for East Kalimantan's transition

A number of guiding actions should be considered to plan East Kalimantan's future roadmaps. It is important not to conflate the province's energy sector transition with its overall economic activities, although this report examines and present examples from both aspects. Given East Kalimantan's outsized coal production, only a meager portion of its coal production are used within the province. The following are some aspects which need to be explored by East Kalimantan moving forward.

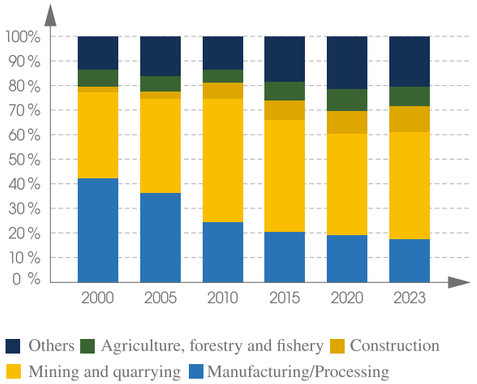
5.1.1 Economic Diversification and Learning from The Past Decline of Oil and Gas Sector

Plans for East Kalimantan economic diversification seemed to have risen in the government's agenda, undoubtedly driven by the accelerating pace of global energy transition and the concerns on the significant reliance on the mining sector (Arumanto, 2023). The provincial government has outlined the importance to expand economic activities beyond the mining industry which may involve optimization of Special Economic Zones (SEZ) and Industrial Zones in the province.

In a recent Local Government Work Plan (RPKD) for East Kalimantan 2025, the head of the Regional House of Representatives emphasized the importance of creating a clear future roadmap (Herdiansyah, 2024).

In a recent regional investment event, several sectors have been highlighted as a potential diversification option such as the oil palm industry and forestry products (Lestari, 2023). Establishing a domestic processing industry to process crude palm oil into more valuable derivative products presents sizeable opportunity for the province, particularly when it is done sustainably.

Figure 9. East Kalimantan Gross Regional Domestic Product Distribution
Source: (BPS Provinsi Kalimantan Timur, 2013, 2024)



East Kalimantan should also look into its own experiences through the rise and decline of its oil and gas sector. Oil and gas have been East Kalimantan's main economic sector in the 1970-1990 period, while the mining industry has developed rapidly since 2007. Between 2009 and 2021, the provinces' oil and gas production had declined by 70 to 80 percent (Badan Pusat Statistik Provinsi Kalimantan Timur, 2021). Lessons from this experience can be invaluable for East Kalimantan as it can provide reflections on the local challenges and opportunities.

It is notable that existing SEZs in East Kalimantan have not reached their full potential, as in the case of Maloy Batuta Trans-Kalimantan SEZ. Since its inauguration in 2019, the SEZ have acquired roughly IDR 100bn of investment, far below the initial target of IDR 34 Tn investment (Sucipto, Status KEK Maloy di Kaltim terancam dicabut, 2024). Development of successful Special Economic Zones require robust planning and strong commitment from both the government, private sector and stakeholders.

SEZ can be instrumental in aiding the province to diversify its economy and to expand the manufacturing sector in East Kalimantan, which currently comprise 15 percent of the economy. Taking lessons from recent SEZ establishments as well as optimization of the existing ones should be explored.

5.1.2 Carefully Capitalizing on the Development of Nusantara Capital

The significance of the IKN Nusantara's development in East Kalimantan can present an opportunity for the province's economy. It is acknowledged that Nusantara's development is managed by the central government through the Nusantara Capital Authority, nevertheless, its development will likely create some level of spillover effect to East Kalimantan's economy.

As the new capital is being constructed, the construction sector has provided a large boost on East Kalimantan's economy (Alexander, 2024). Such growth, however, should also serves as a reminder that construction activities in IKN Nusantara may not be sustainable in the long-term and warrant East Kalimantan stakeholders to identify complementary economic sectors which can be valuable to support IKN Nusantara's activities.

Coal Employment

Global employment in coal industry contracted by more than 220,000 between 2019 and 2022. Coal mine closure along with increased efficiency will shift the coal sector employment (International Energy Agency, 2023)

In Indonesia, 80 to 90% of employment in the industry is typically associated with the mining service companies, which are contracted by the mine owners (Institute for Essential Services Reform, 2022). Significant share of the workers is still at a young age which means that they will likely still look for employment opportunities as the global coal phase out accelerates. Retraining program can be considered for these younger workers with focus on transferable skills.

The IEA's world energy employment report has also noted that coal mines in emerging economies are less mechanized and rely heavily on unskilled workers which raises the transition risks further.

As the landscape shifts, both the central government and East Kalimantan's will need to explore the options for the workers while aiming to allocate funding support for the transition.

According to the International Labor Organization, a for a just transition to take place several guiding principles will need to be adhered to. This includes meaningful social dialogue involving relevant stakeholders and taking early action, as highlighted in a report by the International Institute for Sustainable Development (2022).

5.1.3 Planning for Government Budget Allocation to Support the Transition

The share of coal-related activities to the regional state budget (APBD) is naturally significant for East Kalimantan. Revenue acquired from Revenue Sharing Fund (Dana Bagi Hasil, DBH) for mineral and coal mining activities amounted to roughly 28% of 2022 budget (Badan Pusat Statistik Provinsi Kalimantan Timur, 2024). It is also important to note that a large share of the regional province revenue comes from vehicle-related tax and fuel tax, both of which have strong relationship with local mining activities.

Revenues relating to mining activities can be volatile depending on the global market prices of the mined ores such as coal. Such revenues, however, would likely enter the provincial government's general budget and expenditures. Earmarking the revenues from coal mining activities can assist the process to further allocate expenditures to support transition, while plans to set aside windfall profits during high coal market price can help reduce the volatility of the revenue on the budget (Institute for Essential Services Reform, 2023).

Given the long-term nature of the transition planning, the role of government is essential. While fiscal capacity may be limited, a comprehensive plan to allocate a portion of the government spending to support economic diversification remain instrumental, particularly to tap into the coal revenues during periods of elevated coal price.

Lessons can also be taken from other countries on how to manage a potential shift in coal industry. IEA (International Energy Agency, 2023) reported that in 2016 China initiated several government funding initiatives to assist in training and relocating displaced workers in the coal and steel sector. Such models should be explored further by both the regional and central government with the support of relevant stakeholders, including international funders and the coal industry.

Revenue Category	Trillion IDR	Remarks
Local Government Revenue	16.8	
Subset: Local own-source revenue	9	Includes taxes and retributions, with a significant contribution from vehicle-related tax (IDR 1.2 Tn, 15%) and fuel tax (IDR 4.8 Tn, 29%) as a percentage of the total local government revenue
Subset: Transferred revenue	7.8	Includes transferred revenue from central government, with a significant contribution of Revenue Sharing Fund from the mining and coal sector Land Rents and Royalties (IDR 4.7 Tn, 28%) as a percentage of the total local government revenue.

Table 5. East Kalimantan's 2022 Government Revenue and Select Items Source: (BPS Provinsi Kalimantan Timur, 2024)

5.1.4 Exploring Green Economic Opportunities

To attract meaningful long-term investments East Kalimantan also need to explore the potential use of clean energy sources and its role in the growing green value chain. Renewable energy resources will need to be explored, both within the province and in the neighboring regions as RE, by its geographically-linked characteristics, may be located far from its point of consumption.

The large hydro power potential in neighboring North Kalimantan province holds a promising source for East Kalimantan's clean electricity deployment. It can be used to satisfy regular electricity demand growth, accommodate Nusantara IKN plans or to support industrial development. In addition to strong commitment to develop the hydro project, new investments in transmission line will be needed to evacuate the electricity from the remote regions of North Kalimantan (Just Energy Transition Partnership Indonesia, 2023).

Development plans also need to look beyond the traditional industries, as highlighted by Climate Policy Initiative's report 'From digging to planting' which promotes sustainable plantation in oil palm as well as diversification into other crops. The report primarily focused on Berau regency, but outlined a concept which can be explored and tailored to the various regencies across East Kalimantan (Climate Policy Initiative, 2019).

5. 2 Transition Actions

The following section examines the current landscape East Kalimantan's current energy landscape and presents some case studies.

5.2.1 Government initiatives

Despite being a major coal producing region, the government's energy transition ambition for East Kalimantan remains reasonably ambitious. The Provincial General Energy Plan 2019 – 2050 (Rencana Umum Energi Daerah, RUED) for East Kalimantan outlined a renewable energy mix target of 12.4% by 2025 and 28.72% by 2050 (Pemerintah Provinsi Kalimantan Timur, 2019). By early 2023, renewable energy mix in East Kalimantan stood at 10%.

The Head of the Provincial Research and Innovation of East Kalimantan said that renewables adoption in the region is largely dominated by solar energy and emphasized the need to support other technologies as well (Sucipto, Kaltim, di antara IKN dan tantangan transisi energi, 2023). Similar trend is reflected in the RUPTL 2021 – 2030 which focused on solar power plants (PLTS) and hydro power plants (PLTA). It is notable that only one power plant has a clearly assigned location while the remainder remain to be determined. The majority of solar power generation planned are of smaller scale with larger capacities planned for hydro power.

Aside from PLN's plans, East Kalimantan's provincial government has allocated its provincial budget for developing renewable energy. They allocated IDR 54 bn for solar power plants, IDR 700 mi for small scale biogas and IDR 2.7 bn for solar-powered street lights (Pemerintah Provinsi Kalimantan Timur, 2023). By 2023, nearly 1,700 households in the province are targeted to be powered by solar power plants (Syawarie, 2023).

The provincial government has also built 484 units of small-scale biogas plants, using manure. Most of the construction took place in 2016 with a total of 173 units, while only 28 units were planned for 2023 (Zahira, 2023). With Kalimantan's significant agricultural and forestry-related activities, biomass-based energy will likely need to be explored further while ensuring that they are sourced in a sustainable manner.

No.	Power Plant	Capacity (MW)	COD (Planned commercial operations date)
1.	PLTS Lisdes Kaltim	7.2	2021
2.	PLTS Lisdes Kaltim	5.5	2022
3.	PLTS Dedieselisasi Kaltim	24.81	2023
4.	PLTS Lisdes Kaltim	4.1	2023
5.	PLTS Lisdes Kaltim	3.2	2024
6.	PLTA Kaltimra (Distributed)	200	2025
7.	PLTA Lambakan	18.2	2025
8.	PLTS Kalseltengtimra	50	2025
9.	PLTA Kaltimra (Distributed)	100	2026
10.	PLTA Kaltimra (Distributed)	200	2027
11.	PLTA Kalseltengtimra	200	2029
12.	PLTA Kalseltengtimra	100	2030

Table 6. Planned Renewable Energy Projects in East Kalimantan

Note.: PLTS (Solar PV) ; PLTA (Hydro power) ; Lisdes (Listrik Pedesaan): power generation for villages ; Kaltimra (Kalimantan Timur dan Utara): East and North Kalimantan ; Kalseltengtimra (Kalimantan Selatan, Tengah, Timur dan Utara): South, Central, East and North Kalimantan. Several projects listed are assigned across multiple provinces. Source: (PT PLN (Persero), 2021)

No.	Name	Capacity (kWp)	Note
Solar Power Plant (Photovoltaic, PV)			
1.	PLTS Desa Deraya & Lemper	70.16	For 206 households
2.	PLTS Long Sului	41.49	For 116 households
3.	PLTS Desa Matalibaq	92.97	For 370 households
4.	PLTS Dusun Mului	23.07	For 69 households
5.	PLTS Desa Pegat Betumbuk	25.68	For 84 households
6.	PLTS Desa Ujoh Halang	37.94	For 95 households
7.	PLTS Terpusat Desa Labuang Kallo	27.5	For 96 households, revitalisation
8.	PLTS Atap Kota Samarinda	30	55 spots
Solar Streetlight			
1.	PJUTS Desa Long Hubung		55 units
Small Scale Biogas			
2.	Kampung Linggang Bigung		20 units
3.	Desa Margomulyo		8 units

Table 7. RE Installation Initiative by The East Kalimantan Provincial Government, 2023 Source: (Pemerintah Provinsi Kalimantan Timur, 2023)

Nusantara IKN Green Development. The new Nusantara Capital is planned by the government as a green and sustainable city, accompanied with an elaborate Nusantara Net Zero Strategy 2045 aims (Nusatara Capital Autority, 2023). The Authority in collaboration with a number of international institutions including the Asian Development Bank has developed a roadmap which encompasses various aspects of sustainability.

Within its energy sector planning, IKN aims to utilize 100% renewable energy sources for electricity in 2030, along with an ambitious goal to deploy electric vehicles for both public and private transports. To kickstart the development, PLN is currently in progress of completing the first 50MW solar power plant, with the first 10MW having been connected in February earlier this year (Sinaga, 2024).

By mid-2024, as the new capital is under construction, IKN's population of 200,000 remain small relative to East Kalimantan (Fadilah, 2024). If the city progresses according to the government's plan to relocate government employees, IKN's population significance will grow. From an energy transition perspective, IKN's development allow a test case of developing a green city from scratch.

When completed, PLN's 50MW solar plant can on average serve around 50,000 people, a quarter of IKN's current population. Existing power supply from PLN which are dominated by coal power will remain significant until additional clean electricity is supplied to the IKN. In May 2024, the Nusantara Authority announced the plans by Abu Dhabi's energy company Masdar to explore 200MW of renewable energy project in the new capital, with a potential extension of 2GW capacity (Nusantara Capital Authority, 2024).

It is noteworthy that Nusantara's sustainable development plan extends wider beyond the energy sector. Promotion of efficient buildings, transport sector, waste management and agricultural practices are part of its development.

5.2.2 Private Sector Initiatives

Indika, parent company of Kideco Agung Jaya, have outlined their intention to to diversify their business beyond coal, aiming to achieve 50% non-coal revenue (Indika Energy, 2024). In 2021, the group has established a 409 kWp Solar PV panel in their Kideco's operation area in Paser regency. Indika group have established several new business entities to diversify their business, such as in solar energy and electric vehicle business, albeit many of them are not necessarily located in their traditional mining areas.

It is nevertheless notable that in late 2023 Indika has allocated US$ 21m of funding to build wood pellet production facility in Paser. The wood pellet production capacity is aimed to reach 640,000 tonne annually, with products aimed mainly for the export market (Julian, 2023).

The wood pellet business diversification of Kideco coal miner's parent group presents an interesting example as it is based in the same region with its coal mining business. One of the typical challenges in the energy transition is that new business opportunities -such as clean energy- may not necessarily reside in coal mining regions. Further details on the plan are still limited, however attention is certainly required to ensure that the wood is sourced sustainably.

There are a number of anecdotal activities involving other coal mining companies, mainly involving solar PV installations and other Corporate Social Responsibility (CSR) actions for the local populations. The degree of interest to transition varies quite widely. Other major mining companies such as Kaltim Prima Coal (Bumi Resources Tbk) seemed to be focused more toward coal downstreaming activities (PT Bumi Resources Tbk, 2024), a move which may bring some added value but will likely deepen East Kalimantan's dependence on coal.

Figure 11. Groundbreaking of Wood Pellet Facility in Paser
Source: (Forest Insights, 2023)

5.2.3 Small-scale Community-based Transition: Muara Enggelam Solar Power

Development of distributed power generations remain instrumental for both Indonesia and East Kalimantan as illustrated in Muara Enggelam Village in Kutai Kartanegara regency. The village is located at a lakeside location and has previously relied on diesel power generator. The development of solar power with the assistance of MEMR has been instrumental for the population. Previously, each household would need to pay IDR 300,000 on a monthly basis. Now, they only need to pay a third of the cost to help maintain the solar power facility which is managed by a Village-based Enterprise (Yovanda, 2023).

The solar power facility has been operating for eight years and are still functioning well. The retribution from the local community is used to manage the operation, maintenance and to regularly replace equipment such as the batteries.

Muara Enggelam solar power showcases how renewable energy adoption can play a crucial role in providing access to clean electricity to remote regions, at a lower cost than the alternatives. The case also highlights the importance of engaging with the local community to raise the sense of ownership in managing the facility for the long-term benefit of the society.

Figure 12. Community-based Solar Power Source: (Yovanda, 2023)

06 CHALLENGES AND THE ROAD AHEAD

The landscape and cases presented within the previous sections presents a snapshot of East Kalimantan's situation and ongoing effort to transition the province. The road ahead, nevertheless, present notable challenges, some of which are outlined below.

6.1.Market Signal for Coal Transition Remain Limited

Despite the rising global commitment to accelerate phase out coal and the various restrictions imposed on coal financing, closer to the ground the signal may not be perceivable as Indonesia's coal production reached a record 775 million tonne last year. For local stakeholders, coal demand in both export and domestic markets may look stable.

Under such circumstances, neither the coal companies nor the government may have sufficient immediate incentives to prepare the transition path for East Kalimantan. Current trajectory of the coal miners in East Kalimantan seemed to still focus on maximizing their production. Some are showing indications for diversifying their business, but at a broader level such examples are the minor exception and not the norms.

The recent government move to open up coal mining activities to religious organization further complicates the transition landscape (Soeriaatmadja, 2024). This year, a regulation extended the possibility of granting coal mining permits to entities owned by religious groups. The move was reported to be the fulfillment of an earlier promise made by the President. One of the plans is reported to be located in one of Kaltim Prima Coal ex-mining areas (Hermawan, 2024). For East Kalimantan, this raises the concerns about deepening the province's coal dependency and increasing entanglement with stakeholders' interests on the ground.

While the direction of travel for the global market is clear, stakeholders in East Kalimantan will require improved exchange of information to create a stronger vision for a coal-free future. Such information is unlikely to surface from the coal industry itself, thus require active engagements by various local and international stakeholders with East Kalimantan's stakeholders.

It is often observed that the discussions surrounding coal phase-out can be 'too academic', relying on scenarios which may diverge from the immediate realities. It will be in the interest of the transition initiative to ensure that such engagements can relate well with the local stakeholders and presented with arguments which are market-credible.

6.2 Power Sector and East Kalimantan's Transition

Within the power sector, PLN's strained financial situation coupled with coal-supporting policies such as the domestic coal price cap all present formidable barriers to transition. It is acknowledged that matters pertaining to the power sector and energy policy largely lies beyond the reach of the provincial government authority

However, given the limited capacity of CFPP in the province, there is likely greater flexibility for adding renewable capacity compared to other regions. Java region, by contrast, have much larger CFPP tied into rigid commercial contracts which raises the barrier for RE adoption. The province's room for renewable energy growth should also be more open with the green ambition of Nusantara IKN.

6.3 Funding the Transition

East Kalimantan's transition planning ultimately will require sufficient funding support. In addition to earmarking the government's revenue for transition as outlined in prior section, optimizing the use of Corporate Social Responsibility (CSR) funds from the existing coal industries should also be thoughtfully considered. This is particularly important considering that CSR activities are typically concentrated within the nearby vicinity of the affected mining areas.

Various international initiatives are also ongoing, supported both by bilateral and multilateral initiatives, which can provide assistance in establishing proper assessments, planning and pilot projects for the province.

CLOSING

In closing, East Kalimantan's dependence on the coal industry and the absence of near-term market signal on the coal market may make it challenging to gain strong commitment in the transition plans. The shifting dynamics of the global coal market, however, is inevitable. While the timing of peak coal demand in East Kalimantan's coal export destinations remain to be seen, the direction of travel is clear.

East Kalimantan's provincial government with the support from central government should further explore exchange in ideas with other stakeholders which are undergoing -or have undergone- similar situation, including China's Shanxi province.

As East Kalimantan's coal revenue remain elevated in line with its production level, it is due time to ensure that such budgets are earmarked for its future development. Identifying credible roadmaps, leveraging upon its non-coal natural resources and the development of Nusantara IKN all need to be taken into account.

East Kalimantan has always been a resilient province and is no stranger to shifting economic sectors. The province shifted from its timber focused economy in the 1970s to the oil and gas sector in the 1980s. The rise of coal mining industry since the late 2000s have altered the landscape and the future will present yet another shift and opportunities for the province, especially to venture beyond raw natural resources products.

Economic diversification is not a straightforward exercise. The global market will continue to be in a state of flux while interactions with the central government and neighboring provinces remain a dynamic process. Nevertheless, it is important that the development of East Kalimantan's future roadmaps is based upon robust assessments supported by credible institutions.

Indonesia holds only 3% of the global coal reserves, yet it holds the top position in thermal coal exporter with East Kalimantan at the center stage. The development of the commodity has provided sizeable boost to its economy -along with its challenges- in recent decades, now it must look over the hill for more opportunities as the global coal phase out accelerates.

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SOUTH SUMATRA

TRANSITION AWAY FROM COAL: THE CASE OF SOUTH SUMATRA

01 SOUTH SUMATRA PROVINCE PROFILE

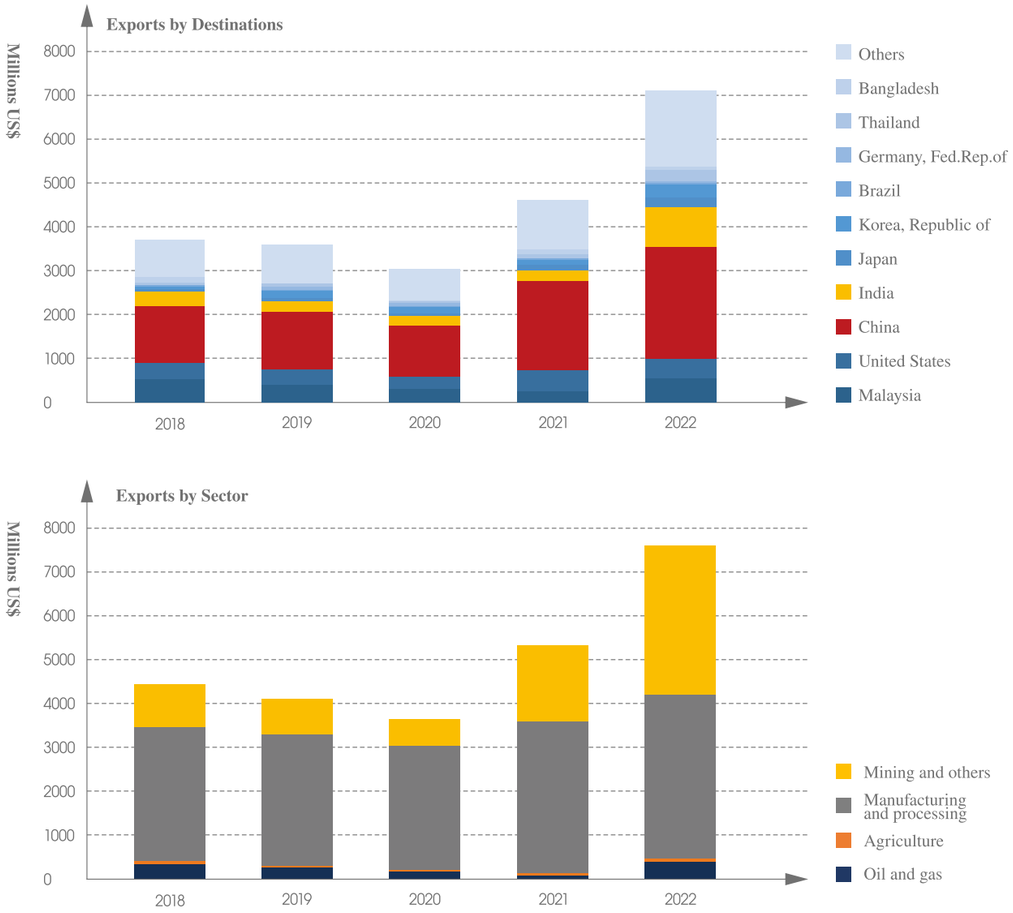
Figure 1. Indonesia and South Sumatra Province Source: Wikipedia

South Sumatra is Indonesia's second largest coal producing province. It is located in the southern part of Sumatra Island, the second most populous island after Java. The total area of South Sumatra is 86,771.68 km2, making it the largest province in the island (Badan Pusat Statistik Provinsi Sumatera Selatan, 2023). The province is divided into thirteen regencies and four cities. Most of the major non-coal industries, such as fertilizer and pulp & paper, reside in region around Palembang, its capital city.

With almost nine million population in 2023 and an average population growth of 1.1%, nearly 20% of South Sumatra's population resides in Palembang (Badan Pusat Statistik Provinsi Sumatera Selatan, 2024). A significant part the population works in agriculture, forestry, and fishery sector. The province has a long history of agriculture development and trade as it was home to one of Indonesia's major historical kingdoms in the seventh century, the Sriwijaya empire.

In recent decades, oil palm and rubber tree plantations have become a major part of South Sumatra's landscape, both covering more than two million hectares in total (Baiduri, 2023). There are 4.5 million people classified as a workforce with 95% employment rate. Among the workforce 42% are high school graduates and 11% are university graduates (Badan Pusat Statistik Provinsi Sumatera Selatan, 2023).

Figure 2. South Sumatra Export Value (Million US$) Source: (Badan Pusat Statistik Provinsi Sumatera Selatan, 2024)



In the last quarter of 2023, South Sumatra's economy grew by 4.94% Year-over-Year (YoY), which was slightly lower compared to national economic growth of 5.04% albeit higher compared to the greater Sumatra Island (4.59% YoY). The slowdown in economic growth was mainly caused by the reduced performance in agriculture, forestry and fishery businesses related to the El Nino weather phenomenon that lowered farming productivity and increased the occurrence of forest fires (Kantor Perwakilan Bank Indonesia Provinsi Sumatera Selatan , 2024). However, the economic downtrend from these sectors was offset by the increase in exports in recent years to countries such as China, India, and Europe. The highest export contributor was coal (US$727 mi or 42.3%), followed by rubber, pulp & paper, and palm oil.

02 COAL DEPENDENCE IN SOUTH SUMATRA PROVINCE

2.1 Overview of Coal Sector

Indonesia's abundant coal reserves are concentrated primarily in the islands of Sumatra and Kalimantan. In 2020, the two largest proven surface coal reserves were located in the province of South Sumatra and East Kalimantan, 4.4 and 9.7 billion tonnes respectively (Figure 3). South Sumatra's surface coal proven reserve comprises around 20% of Indonesia's coal reserve. The province's coal reserves are largely categorized as surface coal reserve, which are located at a depth between 0-100 meters or could be mined through the open pit method (Kementerian ESDM, 2021a).

Figure 3. Indonesia Surface Coal Resources by Province Source: (KESDM, 2021)

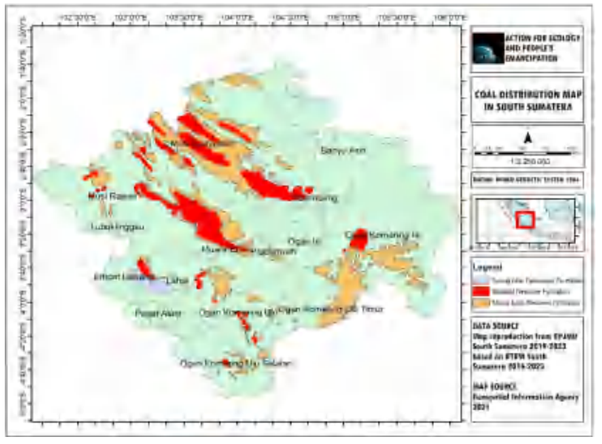


Figure 4. Coal Mining Distribution Map in South Sumatra
Source: (Harahap, Ginting, Distincta, Rushdi, & Burmansyah, 2021)

South Sumatra's coal resources are mostly located further inland, which raises the transportation cost for the commodity. This is in contrast to other major coal provinces such as East Kalimantan which have better access to rivers and seaports. This, coupled with Indonesia's typical low to medium grade coal resources, means that the province's coal economic competitiveness can be more challenged.

The location of coal mines in South Sumatra is spread across several regencies, particularly in Lahat, Muara Enim, and Ogan Komering Ulu with a total concession area of 153,481 hectare (Suprayitno, 2023). The map of the coal mining area in South Sumatra is shown in Figure 4. The total area based on mining permits issued by 2020 was around 626,000 hectares (Harahap, Ginting, Distincta, Rushdi, & Burmansyah, 2021).

In 2023, the South Sumatra's Head of Energy and Mineral Resources Department noted that the province's coal production increased from 90 mi tonne in 2022 (Pahlevi, 2023) to 96.5 mi tonne. 44.3 mi tonne (46%) of this production was for domestic use and 52.2 mi tonne (54%) was for exports (Baiduri, Produksi batubara di Sumsel capai 198 juta ton pada kuartal I 2024, 2024). It is notable that in 2022 coal production increased significantly from 2021's production of 50 million tonne (Muhammad, 2022).

A major contributor to the production is Indonesia's largest coal mining State-Owned Enterprise (SOE), PT Bukit Asam Tbk (PTBA. In South Sumatra, PTBA controls 41 thousand hectares of coal mining areas with 2.6 billion tonne of coal reserve. Their main activities are located in the Tanjung Enim region in Muara Enim regency (PT Bukit Asam Tbk, 2024).

PTBA is of particular interest for South Sumatra's transition as it encompasses around more than 40% of the province's coal production. In South Sumatra, PTBA also owns three CFPP with a total capacity of nearly 1,600MW, roughly 70% of the province's CFPP capacity.

2.2 Coal Market

With a significant share of South Sumatra's coal used domestically, the province's coal market is quite different to East Kalimantan's, which exports nearly 80% of their coal. The domestic use is driven by several factors, including the proximity to demand centers in Java and Sumatra Islands. Both islands comprise close to 87% of Indonesia's electricity demand (JETP Indonesia, 2023). Java holds 56% of Indonesia's population and, along with it, a significant demand for energy. In 2023, Indonesia consumed 213 mi tonne of coal, out of which 121 mi was consumed by CFPP connected to the power grid (Kementrian Energi dan Sumber Daya Mineral, 2024).

Export markets for South Sumatra's coal varies. While China constituted the largest export destination for South Sumatra's entire economy. In the third quarter of 2023, China accounted for 40% of South Sumatra's coal export, while India accounted for 21% (Kantor Perwakilan Bank Indonesia Provinsi Sumatera Selatan, 2023) there is no detailed disaggregated data for its coal export value. PTBA's largest export market in 2023 was India with 13% of total sales, followed by South Korea (9%) and China (6%) (PT Bukit Asam Tbk, 2024). In 2022, a notable boom in coal export occurred with increasing demand post Covid19 recovery. India's heatwave and domestic coal production challenges further amplified their need for coal imports in 2022. Coal exports retreated slightly in 2023 along with decreasing global market price.

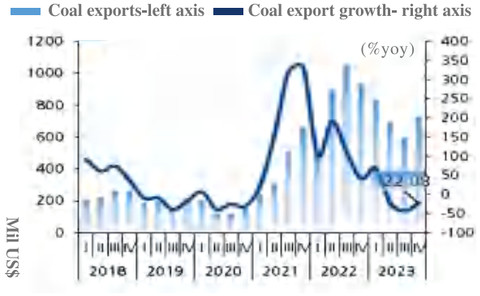


Figure 5. South Sumatra Coal Exports Boomed in 2022
Source: (Kantor Perwakilan Bank Indonesia Provinsi Sumatera Selatan, 2024)

2.3 Coal for Electricity

In the electricity sector, the Coal-Fired Power Plant (CFPP, PLTU) dominates South Sumatra's electricity production with an installed capacity of around 2.2 GW. PLN, as Indonesia's state-owned electricity company, plan to add several additional mine-mouth CFPP based on its Electricity Supply Business Plan (RUPTL) 2021-2030 (PT PLN (Persero), 2021).

Name	Capacity	Status
PLTU MT Sumsel-8	2 x 600 MW	In operation (COD 2023)
PLTU MT Sumsel-1	2 x 300 MW	Delayed
PLTU MT Sumbagsel-1	2 x 150 MW	Construction (COD 2024)

Table 1. Planned CFPP in South Sumatra per RUPTL 2021-2030
Note. COD: Commercial Operation Date. Source: (PT PLN (Persero), 2021)

2.4 Economic Impact of Coal

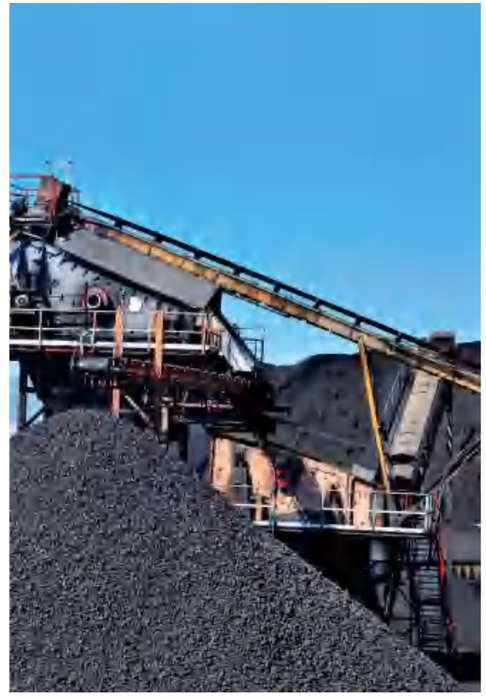
In 2022, coal mining activity contributed IDR 93 trillion or about 16% of the province's Gross Regional Domestic Product (GRDP, PDRB) The mining and quarrying sector, including coal mining, employs about 75 thousand workers (Badan Pusat Statistik Provinsi Sumatera Selatan, 2023)①.

With 15.9% share of the GRDP in 2022, the share of coal mining sector on South Sumatra's economy is significant, especially considering recent increase in coal production. The presence of major SOE such as PTBA in the province also presents an additional nuance for the region.

The concept of South Sumatra as an 'energy silo' to supply Indonesia's energy demand is well outlined in the province's Medium-term Development Planning, RPJMD 2019-2020 (Pemerintah Provinsi Sumatera Selatan, 2019). Development of mine-mouth Coal-Fired Power Plant (CFPP) has also been part of the ambition to capitalize on the coal reserves. Placing CFPP closer to the coal mines aims to reduce transportation costs and improve the coal's economic competitiveness.

In late 2023, the 1.2 GW Sumsel-8 CFPP entered into operation (PT Bukit Asam, 2023). The plant was established as a joint venture between PTBA and China Huadian Hongkong Company Ltd. The plant alone can consume 5.4 mi tonne of coal annually (Muliawati, 2022).

In addition to the mine-mouth CFPP development, 'coal downstreaming' project plans, to process coal into its derivative products, have been promoted by the government as a key policy to maximize South Sumatra's coal resources.



	South Kalimantan	Central Kalimantan	East Kalimantan	North Kalimantan	South Sumatera*
Coal mining share in provincial GDP	17.2%	7.3%	35.1%	17.8%	6.1% (15.9%)*
Coal share in provincial goods export	78.1%	58.0%	75.6%	74.2%	18.9%
Mining and quarrying share in provincial employment	3.9%	6.0%	8.6%	3.6%	1.6%
Credit to mining and quarrying as share total non-financial bank credit	5.0%	0.1%	3.4%	n. a.	0.4%
Estimated mining and quarrying share in total provinciallabourincome	3.5%	7.0%	7.5%	3.8%	1.5%

Table 2. Key Economic Indicators in Coal Producing Provinces in 2020-21 Source: (IEA, 2022)
Note. *Significant changes occurred in South Sumatra during 2022-23 where the share of coal in GRDP increased substantially due to coal production increase. Figure in parenthesis comes from BPS 2023 data. Labour income share is calculated as average wages in each sector weighted by its share in total employment. It includes informal employment and in-kind incomes.

① Throughout this report, 'mining and quarrying' refers to all activities including those related to coal. Both coal and lignite are referred to as 'coal' within this report.

2.5 Coal Down-Streaming

In 2021, the Government of Indonesia developed the Coal Utilization and Development Roadmap, selecting South Sumatra as the site for a coal gasification project to produce DME (Dimethyl Ether). The DME is aimed at substituting the use of Liquified Petroleum Gas (LPG), mainly for cooking, as three-quarter of Indonesia's LPG consumption relies on imports (Kementerian ESDM, 2021a).

In January 2022, President Joko Widodo initiated the groundbreaking ceremony for a 1.4-tonne DME plant in Muara Enim. The event also marked the first groundbreaking of a coal downstream project in Indonesia. The President expected the project to reduce LPG imports by IDR 80 trillion and create 12 to 13 thousand new jobs. If successful, the project is planned to consume six million tonnes of coal annually from PTBA's production.

This project was established as a joint venture between PTBA, PT Pertamina (Persero), and US-based supplier Air Products and Chemicals, Inc.(Kementerian ESDM, 2022). However later in 2023, Air Products and Chemicals, Inc. decided to withdraw from this project. According to Indonesia's Chamber of Commerce, the coal down-streaming project are still experiencing many obstacles due to lack of certainty on the off-taker side (Kontan, 2023). This is expected given that the economics of coal downstreaming can be challenging (Institute for Energy Economics and Financial Analysis, 2020). More recently, PTBA announced that they are having intensive communication with East China Engineering Science and Technology Co., Ltd. as a potential new investor for the project (Wahyudi, 2024).

Similar toother coal down streaming plans such as the methanol project in East Kalimantan, the progress of the DME project is still quite limited. This is despite strong political commitment in providing generous incentives from central government including coal royalty reduction and special coal price for feedstock.

With the accelerating pace of the global energy transition, South Sumatra need to plan its future well in advance. The increasing scrutiny on coal use and commitments toward decarbonization have accelerated the adoption of Renewable Energy (RE) globally and indicate a clear direction of travel which raises the urgency for South Sumatra to transition from coal, as we will explore in later sections.

Figure 6. Groundbreaking Coal Down Stream Project in South Sumatra
Source: (CNBC Indonesia, 2022)

03 IMPACTS OF COAL ON LOCAL SUSTAINABLE DEVELOPMENT

For many years, coal has been dominating the global energy mix and helped transform the global civilization by providing transportable and affordable energy source. Its use, however, has come with significant adverse impacts for the environment and public health. These adverse impacts emerged throughout the coal supply chain, from coal mining, processing and transportation, use, and waste disposal activities (Dai, Dong, Yan, & Xu, 2017). Several of these impacts are presented below along with several case examples in South Sumatra.

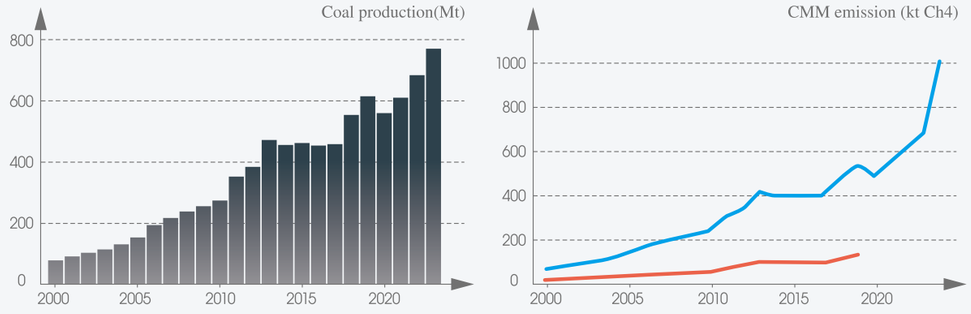
3.1 Emissions and The Climate Crisis

In 2021, the global energy sector contributed more GHG emissions than any other sectors. According to IEA (2023a), coal was the largest emission source related to fuel combustion (International Energy Agency, 2023a). According to Lindsey (2024), the average CO2 concentration at earth's surface in 2019 was higher than at any point in time during the past 800,000 years (Lindsey, 2024). Moreover, coal mines also release methane (CH4), another potent Green House Gas (GHG) which can be eighty times more powerful than CO2 emissions in the near-term.

In a recent study by Ember in 2024, the reported Coal Mine Methane (CMM) emissions –due to the coal mining activities– in Indonesia have increased by 12% annually from 2000 to 2019. This figure was estimated to be up to eight times higher than the latest official estimates. In 2024, Indonesia's CMM emission was estimated to have reached a million tonne annually, equal to a conservative estimate of about 30 mi tonnes of CO2, and higher than the emissions from 200 thousand hectares of wildfire in 2022 (Setiawan & Wright, 2024). There is no disaggregated CMM figure for South Sumatra, but the province's share in the total methane emissions is likely significant given its large share on Indonesia's coal production.

There are various factors which contribute to the global temperature increase, including land-use changes such as land clearing for mining activities. In October of last year, South Sumatra's Climatology station recorded the highest temperature ever recorded in the month of October for the past 48 years, at 37.2 deg Celius (Widyasari, 2023).

Figure 7. Indonesia's Rising Coal Output and Coal Mine Methane Emission Source: (Ember, 2024)



3.2 Air Quality and Dust from Coal Activities

Nearly all activities within the coal value chain from coal mine to its final use produces significant amount of dust and hazardous air pollutants which pose serious risks to the health and environment. Dust generated during mining activities has been linked to several pulmonary diseases such as black lung disease, silicosis, and Chronic Obstructive Pulmonary Diseases (Finkelman, Wolfe, & Hendryx, 2021).

IESR's (2023) coal industry study in Muara Enim regency revealed that the major factor causing air quality degradation comes not only from the coal mining activity but also from the daily truck traffic transporting coal (Institute for Essential Services Reform, 2023). Back in 2021, the disease with the highest occurrence in Muara Enim was the Upper Respiratory Tract Infection, accounting for more than 22,000 cases. Similar problem was reported at Merapi, Lahat Regency with more than 1,700 cases for Acute Respiratory Infections (Yuliani, 2023).

Other cases were also reported in Gandus District, Palembang. The local population who lives close to PT RMK Energy's coal loading port has filed complaints regarding the large amount of coal dust that pollutes the local environment and homes. The Ministry of Environment and Forestry has conducted an investigation and the results show that PT RMK Energy's activities exceed the ambient air quality standards for the Total Suspended Particulate (TSP), PM10, and PM 2.5 parameters (Putra & Arief, 2023).

3.3 Land Changes and Degradation due to Coal Activities

The various stages of coal extraction have also resulted in significant land-use changes and damage to natural resources. The direct and indirect impacts are often observed in landscape destruction impacting agricultural and forested areas, degrading the physical environment, destroying wildlife habitats and ecosystems, damaging recreational lands, causing land subsidence, increasing methane emissions, as well as leading to sedimentation and erosion (Finkelman, Wolfe, & Hendryx, 2021).

In Muara Maung, Lahat, before coal mines were developed there were sizeable plantations and farming activities. In the upstream river areas in Lahat Regency, many of the forest areas have been cleared for mining, the wildlife habitat has been damaged, and the land can no longer accommodate heavy rainfall. As a result, in 2019, there was a large flash flood in nearby Kungkilan river. Black water, a mix of water with coal debris and mud, hit the Muara Maung village. Another flash flood occurred in 2023 in Lematang river which hit several villages. A child died and was swept away by the heavy current, 28 houses were washed away, and 19 houses were seriously damaged (Suprayitno, 2023).

3.4 Water Quality Degradation

Water quality is often impacted by coal mining activities. Mining activities directly impact the quality (e.g., contamination), quantity, and availability of surface and groundwater. Groundwater levels and flow direction can also be altered by underground extraction activities. Surface mining activities typically degrade the surface waters through stream runoff. Over time, these effects can deplete water resources and lead to permanent modifications of local or regional recharge zones.

The water quality in several rivers in South Sumatra has degraded due to coal mining activities. According to the report from the Environment and Land Department (DLHP) of South Sumatra, from 73 monitoring points from various river basin areas, the average Water Quality Index (IKA) was only 58.25 from the target of 67.05 in Regional Medium-term Development Planning (RPJMD). In addition, based on various studies, the hazardous chemical content in water bodies near mining areas such as those in Muara Enim Regency has increased quite significantly. This is further impacting the quality of life for the community that lives near the coal mines (Antara News, 2022). Ironically, back in 1990s, the water from Enim River could be utilized for drinking, washing, and other activities, but since the increase of coal mining activities in the area, the water is no longer suitable for daily use due to heavy mud thickness in the river (Institute for Essential Services Reform, 2023).

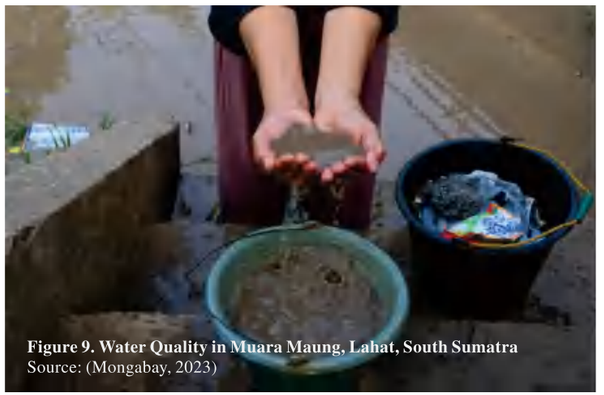


Figure 9. Water Quality in Muara Maung, Lahat, South Sumatra
Source: (Mongabay, 2023)

04 THE URGENCY OF A JUST ENERGY TRANSITION IN SOUTH SUMATRA

In line with the global ambition toward mitigating the climate crisis, The Government of Indonesia (GoI) has undertaken concrete steps to contribute to global climate change mitigation. Some of its efforts are demonstrated by a set of ambitious targets, such as the GHG emissions reduction target, as ratified in the 2015 Paris Agreement document. Indonesia's current commitment is to achieve emission reduction of 31.89% and 43.20% by 2030 compared to Business-as-Usual case, the latter contingent upon international support. These aims are complemented by the national Renewable Energy (RE) share target of 23% by 2025, albeit the realization of national RE share still stood at 13% as of 2023, with coal holding a sizeable 40% share of the national energy consumption (Kementerian ESDM, 2024a).

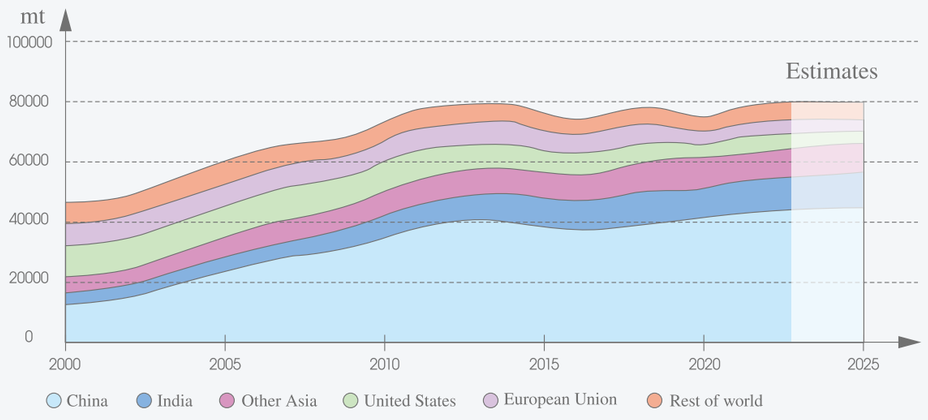
Global and national commitments increase the pressure transition away from coal. Considering South Sumatra's dependence on the coal industry, the following section further elaborates the urgency for the province to plan its future beyond coal and to start early in charting its pathways.

4.1 Rising Global Scrutiny on Coal Use and Declining Renewables Cost

Globally, there has been rising scrutiny on the coal industry and coal-related investments across various parts of the value chain. In the COP26 event in 2021, more than 40 countries have pledged to phase-out coal. Since then, a few other initiatives have been rolled out such as the Just Energy Transition Partnership which aims to assist several coal-reliant countries -including Indonesia- to phase out coal.

In the pursuit of the collective global ambition to reach 'peak emission' various scenarios have outlined the potential of coal demand to peak in the coming years. Global coal use has practically been plateauing in recent decades, with declining use in developed markets albeit compensated by the rise in emerging markets. Recent IEA Coal report in 2023 forecasted global coal demand to continue plateau and decrease within this decade (International Energy Agency, 2023b).

Figure 10. Global Coal Consumption Near Term Outlook Source: (IEA, 2023b)



Future projections and renewables competition. Projections do have a wide degree of uncertainty. The invasion on Ukraine has which shifted coal trade activities from Russia and caused temporary global spike in coal price (Varadhan, 2023). The disruption revealed that the coal transition and the rebalancing of global supply and demand is unlikely to be a smooth ride. In 2023 Indonesia's coal production reached a peak of 775 mi tonnes coal rising from 685 mi tonnes a year earlier (Kementerian ESDM, 2024b).

Such transition, nevertheless, remains inevitable driven by the accelerating pace of global capital allocation to clean energy, overshadowing investments in fossil fuel. The decline of renewable energy costs has spurred massive investments in the renewables in countries such as India and China, South Sumatra's key coal export markets. China, with its 1,500 GW of installed renewables capacity, led the world in 2023 by a significant margin while India's nearly 180 GW capacity placed it in the global top four (Ember, 2024).

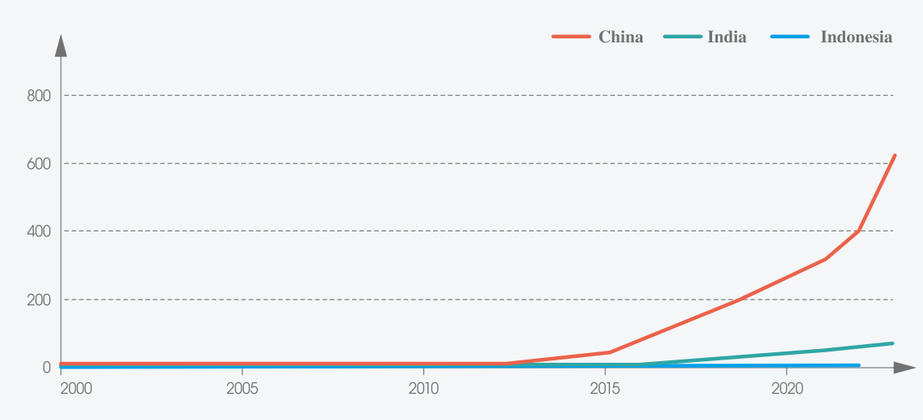
China's 2030 Target. China has outlined ambitious target for clean energy adoption and is currently the world's leader in solar and wind deployment. In 2020, during the UN Climate Ambition Summit, President Xi Jinping outlined a goal to reach 1,200 GW of wind and solar installed capacity by 2030. The country looks set to reach their capacity target much sooner in 2024 or 2025, from practically near zero two decades ago (Afry, 2023).

Clean energy investments are now crucial element for China's development and the country sees the transition as an opportunity, not solely as a threat to their existing coal industry. It is a viewpoint which other regions can learn from. While China's coal consumption remains robust, the pace of renewables adoption meant that the peaking of coal demand is inevitable.

In sync with China's ambition in clean energy, India has outlined a 500 GW of renewable energy capacity target by 2030. In 2023, India has installed roughly 18 GW of RE capacity, bringing the cumulative capacity to about 190 GW as of the first quarter of 2024 (Institute for Energy Economics and Financial Analysis, 2024). The country is also home to the Bhadla Solar Park, one of the largest solar PV power plants in the world with 2.2 GW of capacity, a testament to India's commitment in growing its renewables capacity (Bello, 2021).

Globally, renewable energy development presents a direct competition for coal use in power generation thus it is important for South Sumatra's stakeholders to look ahead beyond the near-term coal demand trends and to anticipate the leading indicators of renewables adoption in both countries.

Figure 11. Increasing Wind and Solar Capacity in India and China (GW) Source: (Ember, 2024)



4.2 Increasing Restriction for Financing for Coal Mines

Retreat of financing in coal-related sector have also been notable with more than 200 globally significant financial institutions outlined their coal exclusion policies (Institute for Energy Economics and Financial Analysis, 2023). More than 50 financial institutions in Asia-Pacific have joined in.

With the ever-rising scrutiny on the coal sector, coal miners will likely continue to face significant challenges to fund their long-term business activities, especially for expansion of new coal mines. In 2022, despite the increasing profits of coal companies related to the coal supply crunch induced by The invasion on Ukraine, coal exclusion momentum by financiers remains strong which suggests that the appetite for coal projects have likely changed for good.

Chinese leader Xi Jinping's statement in 2021 outlining the intent for China to stop building new coal-fired projects abroad further emphasize the shifting global trend. Indonesia's recent coal power build out has mainly relied on Chinese financing -including South Sumatra's Sumsel-8 CFPP- and China's changing position has inevitably altered the investment landscape.

Ultimately, new coal mine investments can take considerable time to reap profits. With an uncertain outlook on the global coal demand, investors are cautious in expanding new production capacity which has a high risk of being 'stranded' as and when its future demand declines (Grantham Research Institute, 2022).

Given PTBA's dominance in the province, it is also important to note that State-Owned Enterprise will increasingly face similar challenges. Investor pressure will eventually cascade to the domestic banks and international bond holders, including those which traditionally fund Indonesia's SOE activities. In 2022 Bank Rakyat Indonesia, one of Indonesia's largest SOE banks have outlined their plan to back away from coal financing. The aggressive move by PTBA and the Government of Indonesia to secure off-takers for PTBA's coal through mine-mouth CFPP and downstreaming plans also emphasized the elevated concerns on long-term coal demand.

4.3 Implications for South Sumatra Coal's Industry

Assuming that coal production is held constant at 96 mi tonnes annually and based on the latest 2020 data of 4.4bn tonnes of surface coal proven reserves, without any further expansion the coal reserves can be exhausted in around 46 years. This would extend beyond President Joko Widodo's pledge at the 2023 Hannover Messe in Germany, that all Indonesian CFPP would be closed by 2050.

Such figures, however, require nuanced understanding as coal exploration and mine expansion activities will likely still take place albeit with a limited speed. The different grades of coal with varying calorific values also introduce additional complexity in forecasting future market situations.

Nevertheless, the rapid acceleration in South Sumatra's recent coal extraction coupled with global restriction in obtaining financing for coal project meant that the province would need to thoughtfully consider its coal sector outlook, as its expansion is heading into the opposite direction of global trends.

According to a study on the future of global coal finance, the coal industry will continue to face a challenging situation. Global investment for new coal mines until 2040 is expected to decrease by 56%. The international coal trade volume in 2035 is also expected to drop and affecting coal producing countries. In addition, it is projected that around 1.5 - 2.5% of global coal mines could be decommissioned each year. A quarter of current global mining capacity could become stranded assets in the next decade and around one-third by 2040.

On the employment side, coal mining which is more labor intensive rather than capital intensive will undergo a structural change. It was estimated that over 2.2 million jobs would suffer from early mines closures around the world, affecting mainly low-and medium-skilled jobs, which represents respectively 48% and 46% of the total number. This risk will be significant for coal-reliant regions, including South Sumatra (Auger, Trüby, Balcombe, & Staffell, 2021).

As the international coal trade is projected to decline in the future, risk for future revenue decline is significant for both the coal industry and the regional government. A natural repercussion of changing demand is stranded assets and increase in unemployment, both of which need to be anticipated.

Just Transition and JETP

Indonesia's Just Energy Transition Partnership (JETP) was launched in 2022 with the support of the International Partners Group (IPG) co-led by the United States of America and Japan. The partnership aims to help several coal-reliant countries such as Indonesia to phase out coal and accelerate renewable energy adoption. The partnership aims to mobilize US$ 10bn of public and US$10bn of private funding, marks the largest energy transition financing package in the world to date.

JETP's Comprehensive Investment and Policy Plan (CIPP) outlined the roadmap toward reducing emissions and defined key investment areas such as the power grids and early coal power retirement. Several of the projects outlined are located in and around South Sumatra, including power grid improvements and power generation facilities.

Within the CIPP, several strategies related with coal phase-out have been outlined, such as: (1) accelerated retirement of CFPP as prioritized by GoI within the Comprehensive Investment and Policy Plan (CIPP) document; (2) restriction of captive CFPP development; and (3) Freezing the existing pipeline of planned on-grid CFPP in the 2021 – 2030 RUPTL document (JETP Indonesia, 2023)

A crucial element of the JETP is the outlining of just transition guiding principles which includes (1) labour-oriented concept, (2) integrated framework for justice, (3) theory of socio-technical transition, (4) governance strategies, and (5) public perception (Institute for Essential Services Reform, 2023)

The 'just transition' concept is crucial as it seeks to cast attention on the population that are most affected by the global energy transition (Grantham Research Institute, 2024). Its importance is even higher for coal dependent regions such as South Sumatra.

05 TRANSITION EFFORTS AND ACTIONS

Transitioning away from a coal dependent economy is a global issue that needs to be tackled. Principally, there are two measures which needed to be taken, to move away from coal and embracing renewable energy as the replacement for coal. The former poses a notable backlash risk from existing coal-related stakeholders. Thus, a thorough planning of the transition process is essential.

5.1 Planning Ahead for South Sumatra's Transition

5.1.1 Government budget allocation for transition

The total planned regional state budget (APBD) of South Sumatra for 2022 budget is around IDR 9.9 trillion, the revenue acquired from Revenue Sharing Fund (Dana Bagi Hasil, DBH) for mineral and coal mining was estimated to amount to IDR 442 bn, roughly 4% of 2022 budget. Official realized figures for the 2022 budget does not provide detailed data for coal-related revenue, but a total revenue increase of around 10% was noted compared to the initial plans.

Coal and lignite mining sector in South Sumatra contributed 15.9% of GRDP in 2023 (Badan Pusat Statistik Provinsi Sumatera Selatan, 2023). It is important to note that this figure jumped significantly from 5 to 6% in 2019-2020. Part of this increase is related to the rapid increase of coal production and coal market price. As noted previously, South Sumatra's economy is more diversified compared to East Kalimantan's but coal industry still plays a significant role.

Revenues related to coal mining activities can be volatile depending on the global market, due to limited data availability we have yet to identify the effect of South Sumatra's coal production increase to the state budget comprehensively. Such revenues, however, would likely enter the provincial government's general budget and expenditures. Earmarking the revenues from coal mining activities can assist the process to further allocate expenditures to support transition, while plans to set aside windfall profits during high coal market price can help reduce the volatility of the revenue on the budget (IESR, 2023).

In addition to the state budget, coal mining activities may have limited multiplier impact in terms of income and employment, as noted in IESR's study on Muara Enim regency. Additionally, they estimated that only 20% of the added value from coal mining activities were allocated to the workers while 78% became company surplus (Institute for Essential Services Reform, 2023).

Given the long-term nature of the transition planning, the role of government is essential. While fiscal capacity may be limited, a comprehensive plan to allocate a portion of the government spending to support economic diversification remain instrumental, particularly to tap into the coal revenues during periods of elevated coal price.

Lessons can also be taken from other countries on how to manage a potential shift in coal industry. IEA (2023a) reported that in 2016 China initiated several government funding initiatives to assist in training and relocating displaced workers in the coal and steel sector. Such models should be explored further by both the regional and central government with the support of relevant stakeholders, including international funders and the coal industry.

Table 3. South Sumatra 2022 Planned Government Revenue and Select Items Source: (BPKAD Sumsel, 2021)

Revenue Category	Trillion IDR	Remarks
Local Government Revenue	9.9	
Subset: Local own-source revenue	5	Includes taxes and retributions, with significant contribution from vehicle-related tax (IDR 1 Tn, 10%) and fuel tax (IDR 1.1 Tn, 11%) as a percentage of total local government revenue
Subset: Transferred revenue	4.9	Includes transferred revenue from central government, with significant contribution of Revenue Sharing Fund and Property Tax (IDR 857 billion, 9%) as a percentage of total local government revenue.

5.1.2 Exploring green economic opportunities and preparing the people

To attract investments from both local and international sources, South Sumatra should thoroughly examine their potential for using clean energy and engaging in the green value chain. It is crucial to investigate renewable energy opportunities both within the province and in neighboring regions. It is also important to consider the local energy demand to meet the small and scattered demand within the province.

Besides having large coal reserves, South Sumatra also has a huge amount of renewable energy potential. South Sumatra ranked as the eighth province with the largest RE potential, with 21.8 GW of RE potential consisting of geothermal, wind, hydro, mini/micro-hydro, solar PV, bioenergy, and municipal waste (Adiatma & Tampubolon, 2019). The largest potential comes from Solar PV with 17 GW. Harnessing the sizeable solar PV potential in the region requires strong commitment and efforts to integrate the RE into the power grid.

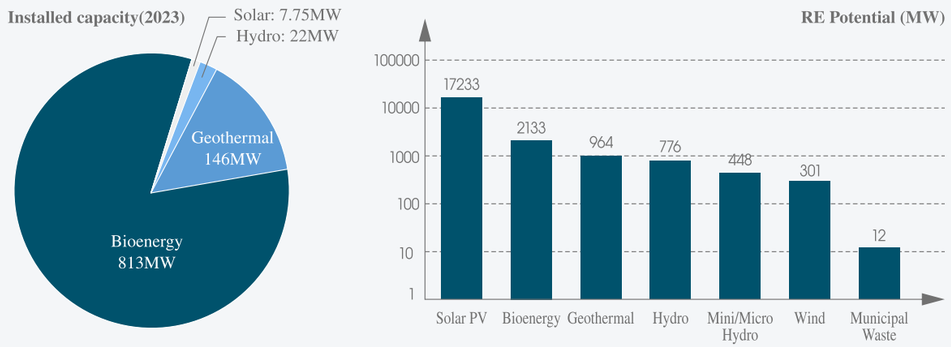
A key component of South Sumatra's RE landscape is geothermal energy. The province is home to several geothermal power plants such as PLTP Lumut Balai (55MW) and PLTP Rantau Dedap (91MW). The former is operated by the state-owned Pertamina Geothermal Energy while the latter is operated by a private company, Supreme Energy. Indonesia owns some of the largest geothermal power potential in the world. The energy is able to provide clean stable power which give it an advantage over other more intermittent RE, particularly to support industrial use. Its development, however, entails considerable risk and time which demand strong technical and financial capacity from the project owners.

The province is also rich in bioenergy which can generate electricity and heat from the burning of biomass or biogas. Such energy sources are more portable as they can be transported to a certain distance while allowing stable source of energy. With 2.1 GW of bioenergy potential, a sizeable portion is likely related to the biomass potential from the province's key crop, oil palm. Nearly all of the installed bioenergy capacity are used as 'captive power' by the plantation-related activities (Figure 13).

In 2022 the area of oil palm plantation in South Sumatra reached 1.1 million hectares with approximately 89 palm oil mills in operation (Badan Pusat Statistik, 2023). Biomass from palm oil production activities can be used to satisfy the mills' energy demand as well as the nearby offices and houses.

Figure 12. Rantau Dedap Geothermal Power Plant
Source: (Antara)

Figure 13. RE Installed Capacity and Potential in South Sumatra (MW) Source: (Kompas, 2024, IESR, 2019)



5.2 Transition Actions

5.2.1 Government Initiatives

In 2020 the provincial government of South Sumatra issued regional energy master plan (RUED) 2020 - 2050 which elaborated their strategic action to promote renewable energy. The policy directions include reducing the export of fossil fuel gradually, increasing the use of geothermal, mini and large hydro, peat land, solar, biogas, and biomass energy.

Within the RUED document, the government also outlined a target to reach renewable energy mix of 21.06% by 2025 and 22.56% by 2050. This target is less ambitious compared to other provinces such as East Kalimantan which placed a 31% RE target.

On a positive note, in 2022 South Sumatra reached 23.85% RE mix figure (Antara News, 2024). This figure, however, has likely been eroded by the entry of the giant Sumsel-8 CFPP into the power grid.

No.	Power Plant	Capacity (MW)	COD
1.	PLTA Tanjung Sakti	114	2029
2.	PLTA Hydro Sumatra (Distributed quota)	90	2025
3.	PLTA Hydro Sumatra (Distributed quota)	160	2028
4.	PLTA Hydro Sumatra (Distributed quota)	400	2030
5.	PLTM Minihydro (Distributed quota)	19	2023
6.	PLTM Minihydro (Distributed quota)	8.8	2024
7.	PLTA Minihydro (Distributed quota)	12.4	2025
8.	PLTP Sumatra (Distributed quota)	10	2024
9.	PLTP Sumatra (Distributed quota)	30	2025
10.	PLTP Lumut Balai (FTP2) #3	55	After 2029
11.	PLT P Lumut Balai (FTP2) #4	55	After 2029

Table 4. RE Project Plans in South Sumatra
Note. PLTA: Hydro power; PLTP: Geothermal power; PLTM: Mini hydro. Source: (PT PLN (Persero), 2021)

It is important for the government to raise its ambition to increase the RE mix in response to the changing landscape as outlined earlier. As a comparison, China's Shanxi Province set an ambitious aim for its new and clean energy sources to comprise half of its installed capacity and one-third of its electricity generation by 2025 (Xinhua Net, 2021).

Within the power sector, PLN has planned several RE projects (Table 4). However, only three projects have a clearly defined locations namely, PLTA Tanjung Sakti, PLTP Lumut Balai 3 and 4[②].The rest are still deemed as "distributed quota", which meant that the location is yet to be determined. This indicates that development of RE plan will still need to be accelerated in the region.

② PLTA: Hydro power plant; PTLP: Geothermal power plant; PLTS: Solar PV power plant

An interesting example is the development 2 MW PLTS Jakabaring solar power plant in the Jakabaring sport complex which was built to support the 2018 Asian Games event. After the event, the project was handed by the provincial government to a Provincial government-Owned Enterprise (BUMD) called PT Sumsel Energi Gemilang (SEG). The enterprise is reported to be the only BUMD which operates a solar power plant as an Independent Power Producer (IPP) and supply its electricity to PLN. PLTS Jakabaring was established with the support of Japan's Joint Crediting Mechanism (JCM) program, in which Japan's funding support was secured in exchange of sharing the emissions benefit between Japan and Indonesia (Wijaya, 2024).

The Jakabaring solar project was selected into the JCM initiative in 2015 (Global Environment Centre Foundation, 2024). A key challenge for the project is that the electricity selling price to PLN was lower (US$0.06 per kWh) than the project's initial expectation of US$0.08 per kWh due to existing power sector regulations. Nevertheless, the project continued to be completed with JCM support and is currently still in operation (Gunawan, 2018).

Figure 14. Jakabaring Solar PV Plant Source: (Liberto, 2022)

5.2.2 Initiatives by the Private Sector

The private sector plays an important role in energy transition in South Sumatra to invest in the RE resources and building cleaner industries.

PTBA, the coal mining giant, has built seven PV power plants for villages around their operative branches within South Sumatra and Lampung, a neighboring province. In January 2024, a 57.5 kWp PV power plant (PLTS) was inaugurated in Muara Lawai, Muara Enim to help irrigate 119 hectares of rice field (PT Bukit Asam Tbk, 2024). Another PLTS built by PTBA is in Karang Raja, Muara Enim. Commissioned in February 2023, the 38 kWp PLTS is used to pump water for irrigation from Sungai Enim to Karang Raja Village through a 1.29 km pipeline (Wijaya, 2024).

PTBA is currently exploring the potential to build large-scale solar PV power plant -up to 200MW- on its post-mining land concessions, including in Tanjung Enim (Fadillah, 2024).

Unfortunately, beyond the anecdotal examples of small-scale clean power initiatives spurred by the coal industry's Corporate Social Responsibility (CSR) program, there are limited examples of their support to help South Sumatra to transition. Such programs should be appreciated, but more robust initiatives are clearly needed.

5.2.3 Smaller-scale initiatives

Eight hours away from the provincial capital of Palembang lies a small micro hydro power plant in Pelakat Village, Muara Enim. The case represents a typical situation in remote regions with limited electricity access. With no access to the state power grid, the villagers started exploring the use of hydroelectricity through their own initiative since late 2000s leveraging upon its higher elevation.

In 2010, the village was selected to be involved in a social program held by Al-Azhar foundation. Through the foundation's engagement with PTBA, additional funding was secured to upgrade the micro hydro power plant equipment and infrastructure to 35 kilo-Watt (kW) capacity.

The construction of the micro hydro plant involved the local community and it was able to supply electricity to around 125 houses in the village along with local schools and public facilities. To maintain the power plant, the villagers paid IDR 15,000 (US$1) per month, half of which to pay the operator's wage while the remainder is used for maintenance.

In 2021, PLN's power grid was extended to the village. Several years ago, some of the villagers were still using electricity supply from the micro hydro given its low retribution charge, but villagers who own larger household appliances started to shift their electricity supply to the more stable power supplied by the national power grid (Maarif, 2021).

This case represents the typical development stages of small-scale initiatives to provide electricity access to remote villages. Such initiatives are typically funded either by government, charity or CSR activities. As the national power grid extends into such villages, the use of the distributed power plants is often displaced by the more stable power supply. The entry of the power grid certainly brings benefits to the villagers, yet it also presents a challenge in establishing off-grid power projects in remote villages, as the risk of being eventually displaced by the power grid.

Figure 15. Micro hydro power in Pelakat Village
Source: (Maarif, 2021)

06 CHALLENGES AND THE ROAD AHEAD

The landscape and cases presented within the previous sections present a snapshot of South Sumatra's situation and ongoing effort to transition the province. The road ahead, nevertheless, presents notable challenges, some of which are outlined below.

6.1 Market Signal for Coal Transition Remain Limited

Despite the willingness of Indonesia to tackle climate change by energy transition action, Indonesia still sees coal as a crucial source of revenue and export. This was also reflected in the National Energy General Plan (RUEN) and in the Provincial Energy General Plan (RUED) of South Sumatra. Indonesia's involvement in the JETP initiative should also be commended as it shows increasing commitment to transition from coal.

Indonesia's intent to transition, nevertheless, will inevitably be interlinked with the motives to gain revenue from coal, as the recent rapid increase in the province's coal production exemplifies.

South Sumatra's dependency to the coal industry will likely remain strong as long as domestic and export market demand remain robust. Nevertheless, concerns on the longevity of the coal industry have been emerging in recent years. This is exemplified by current government-driven efforts to find alternative coal utilization through coal downstreaming projects. Out of ten coal downstream projects planned in Indonesia, three are located in South Sumatra (Kementerian ESDM, 2021b).

Shifting South Sumatra's outlook on coal will require combined changes from both the domestic and export markets. At the domestic end, the government will need to carefully reconsider its coal ceiling price policy which incentivizes coal demand growth is in addition to the Domestic Market Obligation (DMO) which requires all coal producer to allocate at least 25% of their production for the domestic market. Such recommendation to reconsider the current DMO policy have also been outlined by the JETP initiative to allow a more level playing field for renewables to complete with coal.

Within the current trajectory, unfortunately, the political support for the coal sector in Indonesia remains high. As an example, in 2021, the central government through Ministry of Energy and Mineral Resources (MEMR, KESDM) has outlined nine incentives to support coal gasification development in Indonesia. These consisted of, among others, extending mining business permit, exemption of VAT, reallocation of subsidies from LPG and off-take guarantee for the products (Kementerian ESDM, 2021b). Ironically, comparable level of support is largely absent in Indonesia's renewable development. One factor, is likely because the government sees coal mainly as a revenue-generating activity, while internalizing coal sector's negative impact to the environment remains a challenge.

For South Sumatra to build a resilient and stable economy, the government will need to change their priorities and carefully plan, considering the energy transition that is gaining traction globally and within its border.

6.2 Power Sector and South Sumatra's Transition

PLN and the central government hold a large responsibility for the transition of the power sector in South Sumatra. The Provincial government holds limited authority in determining the energy mix of its power sector. Some of these authorities include allocating provincial budget to build small to medium-scale renewable energy power plants, particularly for the remote regions. In addressing such challenges, the central government will need to encourage more involvement from the regional stakeholders in outlining future plans.

One of PLN's cornerstone initiatives in supporting coal phase-out effort in power sector is through the use of biomass. Initiative to use cofiring of biomass in existing CFPP has been explored, including to use 1 to 5% biomass mix in PLTU Tanjung Enim in South Sumatra. By the first semester of 2023 there were 40 PLN's CFPP across Indonesia which implemented co-firing technology using biomass (PT PLN (Persero), 2023). Nevertheless, it should be noted that currently the co-firing technology is only able to reduce a very small part of coal consumption for each CFPP (below 10%). Thus, if not carefully planned, it can be rightly considered as an effort to extend the life of CFPPs operation. Additionally, the sustainability of the biomass sourcing is crucial in assessing the benefits of using biomass.

South Sumatra's transition pathway will need to leverage upon its proximity to energy demand centers such as Java. While ideally clean energy which are produced in the province can be used within its borders, given the significant excess coal power capacity in PLN's power grid, South Sumatra's first transition movement will need to also look for opportunities beyond its borders. The opportunity to supply clean power, whether from geothermal, bioenergy or solar power, to the the neighboring provinces will need to be explored.

6.3 Funding the Transition

South Sumatra's transition from coal will require strong funding support. Fortunately, the province's more diverse economy should allow it to tap into other sources. In addition to earmarking the government's revenue for transition as outlined in prior section, optimizing the use of Corporate Social Responsibility (CSR) funds from the existing coal industries should also be thoughtfully considered. This is particularly important considering that CSR activities are typically concentrated within the nearby vicinity of the affected mining areas.

A case study in Lusatia region in Germany found that there are some lessons learned of the prerequisites required to achieve a successful transition in coal-reliant regions, those are (1) pre-emptive approach, in this case, creating suitable framework to gain trust among affected stakeholders; (2) establishing good framework conditions, which includes the institutional and financial framework to organize the transition process; (3) social compensation, providing appropriate compensation before any negative impact are felt; (4) community and citizen participation, in decision-making process; and (5) political leadership, which is required to make the changes necessary (Greenpeace, 2019)

Various international initiatives are also ongoing, supported both by bilateral and multilateral initiatives, which can provide assistance in establishing proper assessments, planning and pilot projects for the province.

CLOSING

South Sumatra's current condition poses significant challenges to transition away from coal. On a positive note, the province's reliance on the commodity is not as pronounced as other regions such as East Kalimantan. Its long history of economic activities in agriculture and trade meant that the province economy is more diversified.

Within the power sector, sizeable bioenergy capacity is present, but are largely used for self-use in agriculture mills. The province will need to further explore its renewable resources for use in wider application beyond these agricultural activities.

Thus far, there has been limited examples where the coal industry is preparing to transition, from both the SOE and the private sector. The rapid increase in coal production is a clear example how many parties are attempting to capitalize on the coal resources as best they can. Central government's strong support to establish coal downstreaming project -and its flagship DME project- in South Sumatra further complicates the situation and potentially will deepen South Sumatra's reliance on coal.

Nevertheless, the global energy transition is already in motion. At the domestic front, Indonesia's plan to phase down its CFPP poses a real risk on the sustainability of South Sumatra's coal production. China and India's renewable adoption and focus on domestic coal production amplifies the risk of South Sumatra's coal export destination.

While there is no easy way out, it is wise for the province to start allocating its funding and plans for its future. The private sector will have a role to play, but a strong signal from both central and provincial government is clearly needed, to see coal beyond a short-term revenue-generating activities.

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Benchmarking for Transitions (2024)

Province			Shanxi Province	East Kalimantan Province	South Sumatra Province
Province Profile	Population		34.6599 million	3.9 million	9 million
	Area		156,700 km^2	127,000 km^2	86,700 km^2
Coal	Coal Reserves		48.31 billion tons	9.7 billion tons	4.4 billion tons
	Main Method of Mining		Underground coal mines	Open-pit coal mines	Open-pit coal mines
	Annual Production (Year)		1.377 billion tons (2023)	294 million tons (2021)	96.5 million tons (2023)
	Estimated Remaining Mining Time		35 years	33 years	46 years
	Installed Coal-fired Power Capacity		72.06 GW	703 MW	2.2 GW
	Total Installed Power Capacity		133.03 GW (2023)	1.06 GW (2021)	
	Installed Coal-fired Power Capacity / Total Installed Power Capacity		54.2%	66%	
	Economic Dependence (Contribution to GDP)		31.7% (2022)	35.1% (2021)	15.9% (2022)
	Employment Dependence (Employment and the Share)		926,400	149,000	75,000
			Accounting for 45.28% of the province's total industrial employment	Accounting for roughly 8.6% of the total employment	Accounting for 1.75% of the total employment
	Coal Transferred Outside the Province or Exported		59.96% coal transferred outside (2023)	235 million tons, 79.93% (2021)	52.2 million tons, 54% (2023)
Renewable Energy(RE)	Installed Capacity Target	2025	50%	12.4%	21.06%
		2030	More than 60%		
		2050		28.72%	22.56%
	Status quo	Share of Installed RE Capacity	39.9% (2023)	10% (Beginning of 2023)	23.85%(2022)
		Installed RE Capacity	53.09 GW (2023)		175.75 MW (2023)
Transition Background	International	Climate responsibility	China is not only the largest coal producer and consumer but also the largest emitter of carbon dioxide in the world.	Indonesia is the third largest coal exporter and the fifth largest greenhouse gas emitter in the world.	
		International support		A number of initiatives such as the Just Energy Transition Partnership (JETP), which aim to assist several Indonesia and a few other coal-reliant countries to phase out coal, have been rolled out.	
	National	Transition commitments	China strives to achieve carbon dioxide peaking by 2030 and carbon neutrality by 2060. By 2030, carbon dioxide emissions per unit of GDP should fall by more than 65%, compared to 2005.	JETP's Comprehensive Investment and Policy Plan (CIPP) has outlined the roadmap toward emission reduction and defined key investment areas such as the power grids and early coal power phaseout. (1) Accelerated phaseout of CFPP as prioritized by Indonesian government within the CIPP; (2) Restriction of captive CFPP development; and (3) Freezing the existing pipeline of planned on-grid CFPP in the 2021 – 2030 RUPTL document.	
		Transition targets	To accelerate the pace of coal reduction, the province will strictly curb the growth of coal consumption during the 14th Five-year Plan (2021-2025) period and gradually reduce it during the 15th Five-year Plan (2026-2030) period. 1) By 2025, the share of non-fossil energy consumption is expected to reach 20% or so, with energy consumption per unit of GDP to be reduced by 13.5% and carbon dioxide emissions per unit of GDP by 18%, compared to 2020. 2) By 2030, the share of non-fossil energy consumption should increase to about 25% and the carbon dioxide emission per unit of GDP should be reduced by more than 65%, compared to 2005.	1) Indonesia has set the goal of increasing the share of RE to 23% by 2025. 2) The Government of Indonesia has outlined a target to reduce 31.89% of Green House Gas emissions by 2030, with a conditional reduction target of 43.2%, subject to international support. 3) Joko Widodo, President of Indonesia, pledged at the 2023 Hannover Messe in Germany that all Indonesian CFPP would be closed by 2050.	
		Transition opportunity		The significance of the IKN Nusantara's development in East Kalimantan can present an opportunity for the province's economy.	

Benchmarking for Transitions (2024)

Province		Shanxi Province	East Kalimantan Province	South Sumatra Province
Existing Transition Policies and Actions	Local Policy	1) Energy transition is being carried out in a top-down approach to create a low-carbon, green new energy system. 2) Support for transition of coal industry workers is being provided to ensure a just transition. A) During the capacity reduction period, Shanxi Province explored various ways of placement to meet the reemployment need of layoffs from the coal industry: internal phaseout and internal transfer within coal enterprises; employment opportunities outside coal enterprises, such as job transfers and labor export, entrepreneurship, and public welfare positions. B) It has released several employment policies in relation to the energy industry with a focus on expanding channels for resettlement and re-employment, strengthening technical training, improving social security connection, and providing backup public welfare posts for the workers. 3) Land is restored in affected areas to improve the quality of life in the community.	1) East Kalimantan's provincial budget has been allocated for developing renewable energy. 2) The Nusantara Net Zero Strategy 2045 aims have been outlined in detail. 3) Great importance has been attached to formulate outlined future roadmaps.	1) In 2020 the provincial government of South Sumatra issued the regional energy master plan (RUED) 2020 - 2050 which elaborated their strategic action to promote renewable energy. The policy directions include reducing the export of fossil fuel gradually, increasing the use of geothermal, mini and large hydro, peat land, solar, biogas, and biomass energy. 2) Government budget allocation for transition; Exploring green economic opportunities and preparing the people 3) PT PLN has planned several Renewable Energy (RE) projects
	Industry Actions	1) Shanxi Province has increased efforts to develop the coal bed methane (CBM) to promote low-carbon comprehensive utilization of CBM. 2) The exploitation of both coal and CBM has been accelerated to improve the utilization efficiency of coal mine gas. 3) Modern "zero-carbon mines" are constructed to build a clean and low-carbon energy system. 4) Efforts have been made to promote the development and utilization of hydrogen so as to create a new highland for the development of the national hydrogen industry.	1) Indika, parent company of Kideco Agung Jaya, have outlined their intention to diversify their business beyond coal, aiming to achieve 50% non-coal revenue. 2) Indika group has established several new business entities to diversify their business, such as solar energy and electric vehicle business, albeit many of them are not necessarily located in their traditional mining areas. 3) The wood pellet business diversification of Kideco coal miner's parent group has been established.	The private sector plays an important role in energy transition in South Sumatra to invest in the RE resources and building cleaner industries. 1) PTBA, the coal mining giant, has built seven PV power plants for villages around their operative branches within South Sumatra and Lampung, a neighboring province.
	Social Initiatives and People's Livelihood Programs	By May 2021, Shanxi Province has built and connected to the grid 5,532 photovoltaic poverty-alleviation power plants, which brings more than CNY 1.8 billion of revenue from power generation each year. It is actively carrying out various strategies in the field of low-carbon transport, vigorously promoting new energy buses and taxis, strengthening the construction of charging infrastructure, and creating an efficient green and low-carbon transport system. By the end of 2023, there have been 14,900 new energy buses in Shanxi province, accounting for 94.2% of its total number and 24,800 new energy taxis, accounting for 59.8% of its total. It is expected that by the end of 2025, the total number of charging piles in the province's highway service areas will reach 1,349 and that of parking space with charging guns will reach 2,562.	Small-scale Community-based Transition: Muara Enggelam Solar Power	Eight hours away from the provincial capital of Palembang lies a small micro hydro power plant in Pelakat Village, Muara Enim. The case represents a typical situation in remote regions with limited electricity access. With no access to the state power grid, the villagers started exploring the use of hydroelectricity through their own initiative since late 2000s leveraging upon its higher elevation.
Challenges	Market Signal	China has not come up with an overall roadmap for coal phaseout yet.	1) Market signals for coal transition remain limited. Stakeholders still hope to gain revenue from coal. 2) The provincial government holds limited authority in determining the energy mix of its power sector.	1) Market signals for coal transition remain limited. Neither coal companies nor the government has received direct incentives. 2) PLN is witnessing tight financial conditions and supporting policies to the coal industry such as the domestic coal price cap still exist.
	Social Welfare and People's Livelihood	The coal industry involves a big population. The employees in the industry are often equipped with very limited skills, thus creating great resettlement and re-employment pressure. No stakeholder participation mechanism has yet been established. Besides, shortage of technical staff in renewable energy and other high-tech industries makes it difficult to meet the need for transition professionals.		
	Technical Barriers	The efficiency of energy utilization is relatively low. A balanced approach in low-carbon energy transition is desirable to ensure both high quality energy development and energy security. Limited space restricts the large-scale development of renewable energy. Lack of technological innovation capabilities will hamper the development and application of low-carbon technologies. There are barriers to the promotion of low-carbon technologies.		
	Lack of Funds	As fiscal support for coal-based economies is declining, the impetus for transition is likely to weaken. Not all the profits from coal production can be used to support the development of coal-producing regions. Regional transition is still in short of funds, and the market-based social capital attraction mechanism is not yet established. There are still problems in practice. For example, funds are not integrated and there is a lack of evaluation measures.	East Kalimantan's transition planning will require sufficient funding support.	Southern Sumatra's transition planning will require sufficient funding support, and optimizing the use of Corporate Social Responsibility (CSR) funds from the existing coal industries should be thoughtfully considered.