Redefining Future Jobs

Implication of coal phase-out to the employment sector and economic transformation in Indonesia's coal region

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Executive Summary

Despite the short-term fluctuation and recent demand surge, the global coal demand is expected to undergo a structural decline in the long term. IEA (2021) and BP (2022) predicted that global coal demand will drop 0.9% and 1.4% per year for the next three decades, respectively. In their sustainable development scenario, both projected a more rapid coal decline. Stronger climate commitments and economic forces are driving the global coal decline. Major coal users such as China, Japan, South Korea, the US, the EU, and South Africa improved their emission reduction targets in their latest NDC updates, with some countries have even set their coal phase-out targets. From an economic perspective, building renewable power plants would be cheaper than running existing coal power plants by 2030. Funding coal projects would be difficult as many international financing institutions become aware of the associated risks.

Domestically, despite the net-zero commitment, the current energy policy would result in increased coal consumption. In the power sector, the MEMR and PLN plan to stop building new coal power plants by 2030. They also intend to start retiring old coal plants starting from 2030, which will result in reduced coal consumption by the power sector. However, industrial demand is expected to keep increasing as no policy exists to stop coal use in this sector. The government's plan to develop downstream coal industries such as coal-based DME and methanol will also add to the domestic coal consumption. However, if Indonesia wants to pursue a more ambitious climate action compatible with Paris Agreement, domestic coal consumption should decline more rapidly. To achieve net-zero emissions by 2050, IESR (2021) predicts that coal will be phased-out from Indonesia's energy system by 2045.

These international and domestic coal policies would affect future coal production and export. In the current commitments scenario, which assumes the Stated Policy Scenario (STEPS) from IEA's world energy outlook and current domestic energy policy, Indonesia's coal production will slightly increase to around 600 million tonnes in 2025 before declining to around 500 million tonnes by 2050. In the accelerated coal decline scenario, which assumes that countries adopt more aggressive coal phase-out policies compatible with Paris Agreement, coal production will decline by 20% by 2030, 60% by 2040, and 90% by 2050. Under this scenario, coal production will drop to 70 million tonnes in 2050.

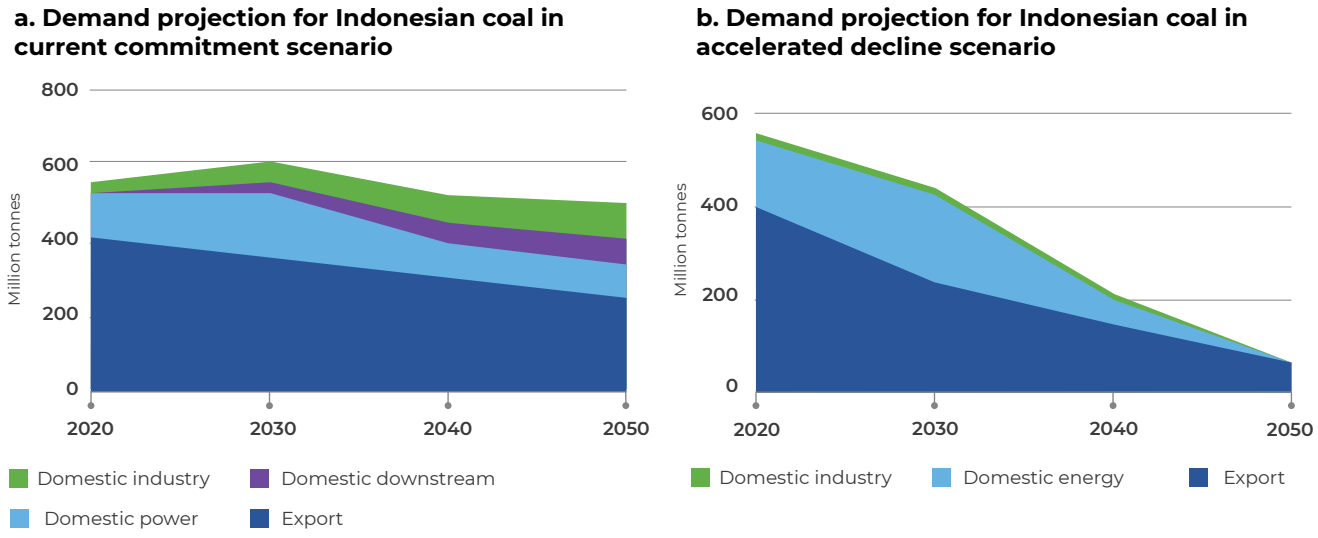

Figure ES1. Demand projection for Indonesian coal in current commitment scenario (a) and accelerated phase-out scenario (b).

Declining production would create negative impacts on the employment along the coal value chain from production, processing, transportation, and end-use. In 2020, there were around 250,000 workers directly employed in coal-mining businesses, which is only 0.2% of total employment. However, in several coal-producing provinces, the share of coal-related employment is significantly higher, at 11% in East Kalimantan, 3% in South Sumatra, and 4% in North Kalimantan. About 80-90% of the coal employment comes from mining services companies. These coal workers are mostly men below the age of 50 with high school or lower-level education and well paid. These particular characteristics make it difficult for coal workers to switch to other industries.

As coal production is expected to decline, coal employment is likely to see a similar trend. The employment rate could decline even more rapidly due to reduction in labor intensity. Labor intensity is more likely to decline due to improved productivity and falling coal price. By 2050, there could be 25,000-252,000 job losses in coal industries, excluding those in power plants and user industries, depending on how rapid countries phase-out coal and labor intensity decrease. However, these impacted coal workers are largely unaware of the unemployment risk they will face in the future.

As most workers are under 50 years old, they would likely remain in the job market when coal unemployment starts in about 2030. The older workers could be prepared for early retirement, while internships could be suitable for younger workers. Some workers with transferable skills such as management, administration, electrician, or mechanic could be retrained to adapt to new jobs. A more intensive reskilling program would be needed for those with specific skills not relevant to other industries such as heavy machine operators. In addition to training programs, additional short-term employment could be created by promoting local entrepreneurship, providing better infrastructure to surrounding areas, moving the workers to alternative roles in the same company, or employing them in coal phase-out-related jobs such as mine reclamation and renewable energy installation. In the case of accelerated coal decline, unemployment benefits and social safety nets could help minimize the impact on the workers.

Few regions are more economically-dependent on coal than others. Coal decline would likely to affect these regions more severely. Few provinces make up over 95% of national coal production, namely East Kalimantan at 48%, South Kalimantan at 32%, South Sumatra at 9%, North Kalimantan at 3%, and Central Kalimantan at 3%. In these provinces, coal contributes significantly to their GRDP, over 15% in East Kalimantan, South Kalimantan, and North Kalimantan. At the regency level, the share of coal in GRDP is often higher. Coal mining is also important to the local government's revenue through royalty and land rent. However, contrary to its major contribution to GRDP and government revenue, coal mining creates little value-added, few employment opportunities, and has high economic leakage, compared to other industries. It also benefits those with higher economic status, thus perpetuating inequality. A transformation from coal-dependent to a diversified economy could improve the social and environmental benefits.

Based on previous coal transition experiences in other countries, there are several enabling factors that are necessary for a successful transformation. The first aspect is the role of national and local government in establishing long-term strategies, policies, and regulations to attract non-coal investments and support affected communities. The second aspect focuses on a gradual and participatory approach to avoid another economic dependency on one sector. The third aspect emphasizes measures to be taken for the impacted communities such as support for the workers, development of local infrastructures, and availability of financing. The fourth aspect views the local characteristics of coal regions as comparative advantages that influence the transformation pathway.

Table ES1. Enabling conditions for successful economic transformation identified in the experiences in other coal regions.

Aspects	Enabling conditions
Government interventions	Central government actions
	Regional and local government participations
	Policies
Transformation approaches	Polycentric approach
	Gradual economic transformation
	Institution establishment
Community revitalization	Workers facilitation
	Local development
	Financing availability
Comparative advantages	

The gradual transformations observed in the previous experiences follow a similar pathway to the Clark-Fisher economic transformation model. The model suggests that the economy shifts from predominantly agriculture and mining to the manufacturing and construction industry and later to the service and knowledge economy. Following this pattern, the economic transformation in coal regions should start with modernization in the agriculture and mining sector to improve productivity and minimize their negative impacts. The next step is to strengthen the existing key industries with a high multiplier effect, such as the food and chemical industries. In addition, infrastructure development, environmental restoration, and human capital improvement are necessary to prepare for the service and knowledge economy.

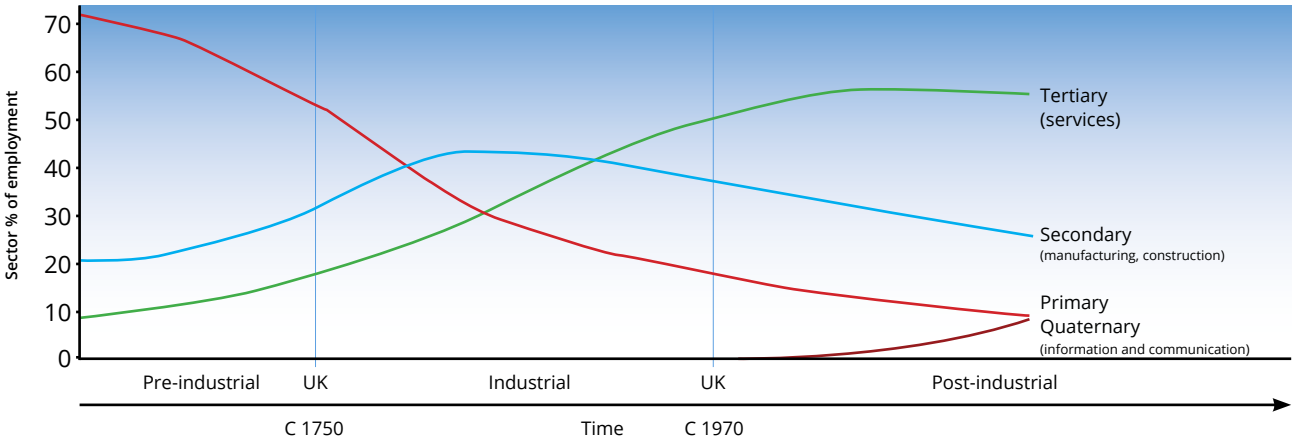

Figure ES2. The shift of economic structure according to the Clark-Fisher model

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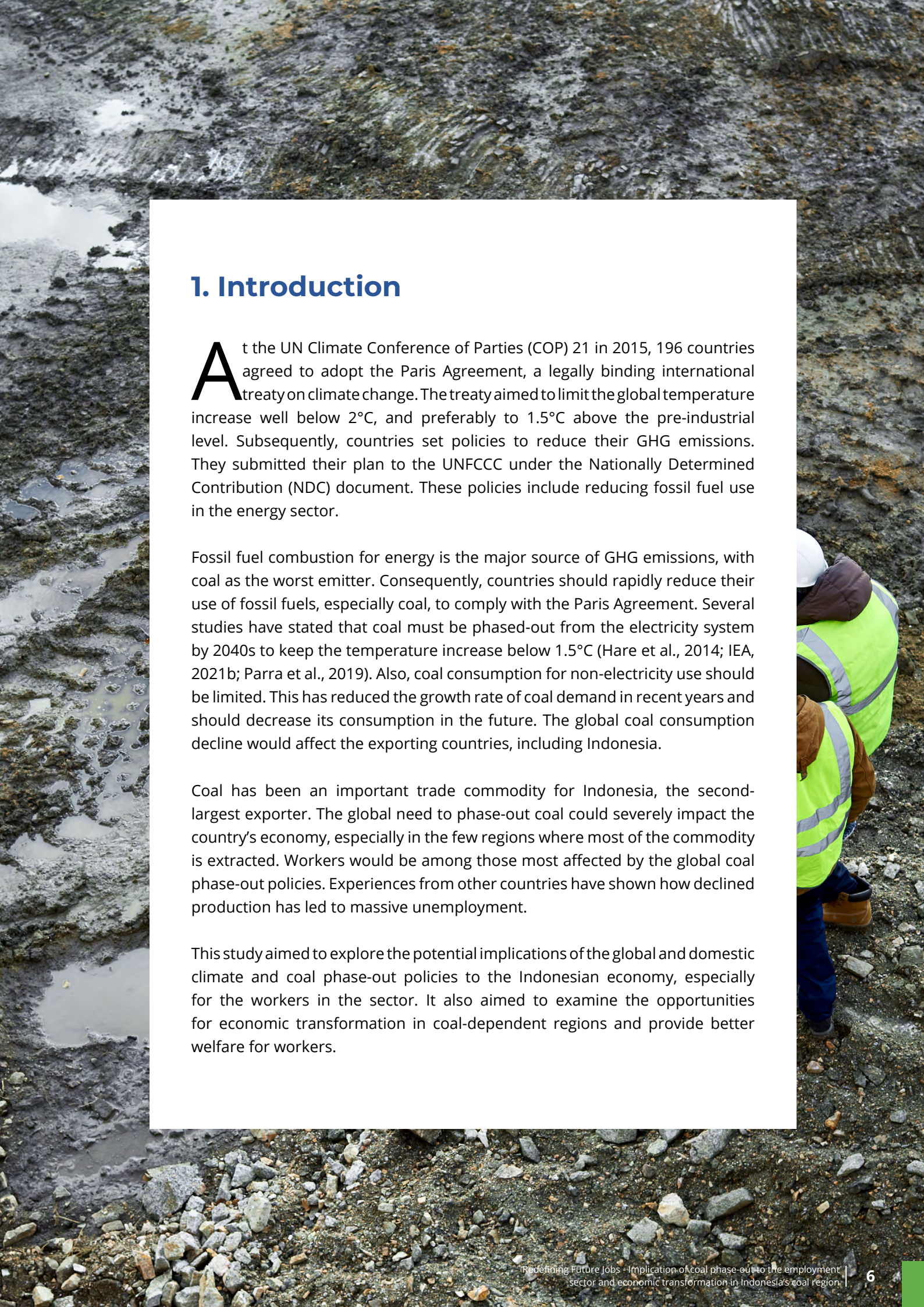


1. Introduction

At the UN Climate Conference of Parties (COP) 21 in 2015, 196 countries agreed to adopt the Paris Agreement, a legally binding international treaty on climate change. The treaty aimed to limit the global temperature increase well below 2°C, and preferably to 1.5°C above the pre-industrial level. Subsequently, countries set policies to reduce their GHG emissions. They submitted their plan to the UNFCCC under the Nationally Determined Contribution (NDC) document. These policies include reducing fossil fuel use in the energy sector.

Fossil fuel combustion for energy is the major source of GHG emissions, with coal as the worst emitter. Consequently, countries should rapidly reduce their use of fossil fuels, especially coal, to comply with the Paris Agreement. Several studies have stated that coal must be phased-out from the electricity system by 2040s to keep the temperature increase below 1.5°C (Hare et al., 2014; IEA, 2021b; Parra et al., 2019). Also, coal consumption for non-electricity use should be limited. This has reduced the growth rate of coal demand in recent years and should decrease its consumption in the future. The global coal consumption decline would affect the exporting countries, including Indonesia.

Coal has been an important trade commodity for Indonesia, the second-largest exporter. The global need to phase-out coal could severely impact the country's economy, especially in the few regions where most of the commodity is extracted. Workers would be among those most affected by the global coal phase-out policies. Experiences from other countries have shown how declined production has led to massive unemployment.

This study aimed to explore the potential implications of the global and domestic climate and coal phase-out policies to the Indonesian economy, especially for the workers in the sector. It also aimed to examine the opportunities for economic transformation in coal-dependent regions and provide better welfare for workers.

2. Impact of climate mitigation and net-zero emission commitments on Indonesia's coal sector

2.1. The global climate mitigation and coal phase-out policies

In 2020, global GHG emissions declined significantly due to the pandemic that caused economic contraction worldwide (Tollefson, 2021). However, the emissions reduction was still lower than the 7.6% per year needed to keep the 1.5°C target in the Paris Agreement (UNEP, 2019). Later, the emissions rebounded as economic activity recovered in 2021 (Liu et al., 2022). Global CO2 emissions from the energy and industry sector declined by 5.2% in 2020, but increased by 6% in 2021 to a new all-time high, partly supported by adverse weather and the energy market (IEA, 2022). While fossil fuel demand reduced markedly in 2020 due to the pandemic, renewables growth remained positive (IEA, 2021a), recording the highest annual growth of 500 TWh in 2021.

As countries headed towards COP 26 in 2021, they consider the climate crisis more seriously by submitting their updated NDCs. In July 2021, the Climate Action Tracker found that 71 countries have submitted or proposed the updated NDCs. At least 22 countries have submitted or proposed improved emission reduction targets[1]. These include major coal users, such as China, Japan, South Korea, the US, the EU, and South Africa (Climate Action Tracker, 2021). Moreover, countries strengthen their commitments to moving away from fossil fuels, especially coal. Germany, the largest coal consumer in the EU, became the thirteenth country to commit to phase-out coal power plants. More countries are scaling down their plans to build new coal power plants, except a few countries, including China (Myllyvirta, 2021).

Coal is also pushed away due to economic reason. Building new coal power plants is not economically sensible as renewables technology becomes cheaper. Building new renewable plants would be cheaper than running existing coal plants worldwide by 2030 (Carbon Tracker, 2021). Moreover, funding coal projects becomes difficult as international financial institutions start to acknowledge the associated transition risk (Prasojo, 2021). In their latest summit, the G7 countries agreed to support mandatory climate-related financial disclosures. They also agreed to end financial support for international unabated coal power plant projects by the end of 2021 (G7, 2021).

Global coal consumption has stagnated since 2014 due to the steady decline in most OECD and slowing growth in non-OECD countries. The consumption declined for two consecutive years in 2019 and 2020, reaching the lowest demand of the decade (BP, 2020; IEA, 2021a) before the recent surge in 2021. Nevertheless, in the long run, the WEO 2021 estimated in its Stated Policies Scenario (SPS) that the global coal demand would decline by about 0.9% annually over the next three decades (IEA, 2021b). In its New Momentum Scenario that captures the current progress in global energy system, BP also estimated that the coal demand would continuously decrease by about 1.4% yearly, resulting in a 35% decline by 2050 (BP, 2022). Both projections' sustainable development or net-zero scenarios estimated a more rapid decline.

These global changes affect the Indonesian coal industry since most commodities are exported. In 2020, over 70% of coal produced was exported, with China and India accounting for 55% of the export market. The rest were distributed to mostly East and Southeast Asian countries (MEMR, 2021). Arinaldo (2020)

[1] The European Union is accounted as one country in the analysis

examined the new changes in global and domestic coal policies and projected that Indonesian coal demand for domestic consumption and export would only increase until 2025, then reduce by about 45% in 2050.

2.2. The implication of climate mitigation commitments to Indonesia's coal production

The international and national climate and energy policy changes would affect domestic coal production. It is unlikely to predict the pace of declining demand for coal because of rapid policy changes in response to climate constraints. However, each update of the last six editions of WEO (2016-2021) projected a further decline in the long-term coal demand. This means that countries are improving their plans to reduce future coal consumption. However, the short-term projections have fluctuated, especially after the pandemic hit in 2020.

This study considered two scenarios: current commitment and accelerated phase-out. Rapid coal phase-out in importing countries is assumed for accelerated scenario, following the Sustainable Development Scenario (SDS) in IEA's WEO 2021 for international context and Best Policy Scenario (BPS) in IESR (2021) for domestic context. The current commitment scenario is based on the stated policy scenario (STEPS) of IEA's WEO 2021 for the international demand. For national demand, it uses Indonesia's power sector net-zero plan by MEMR and PLN for the power sector, coal downstream industries plan by MEMR, and assumes increased industrial consumption. The increase in industrial consumption is calculated by extrapolating each industry sector's historical GDP growth.

International demand

Indonesia exports coal mostly to Asian countries, with China and India taking about half the export. Other East and Southeast Asian countries take the rest of the export. Export to other regions such as Europe and America is negligible. Figure 1 shows the flow of the global thermal coal trade in 2019. Therefore, only demand from Asia Pacific countries is included in the international demand projection.

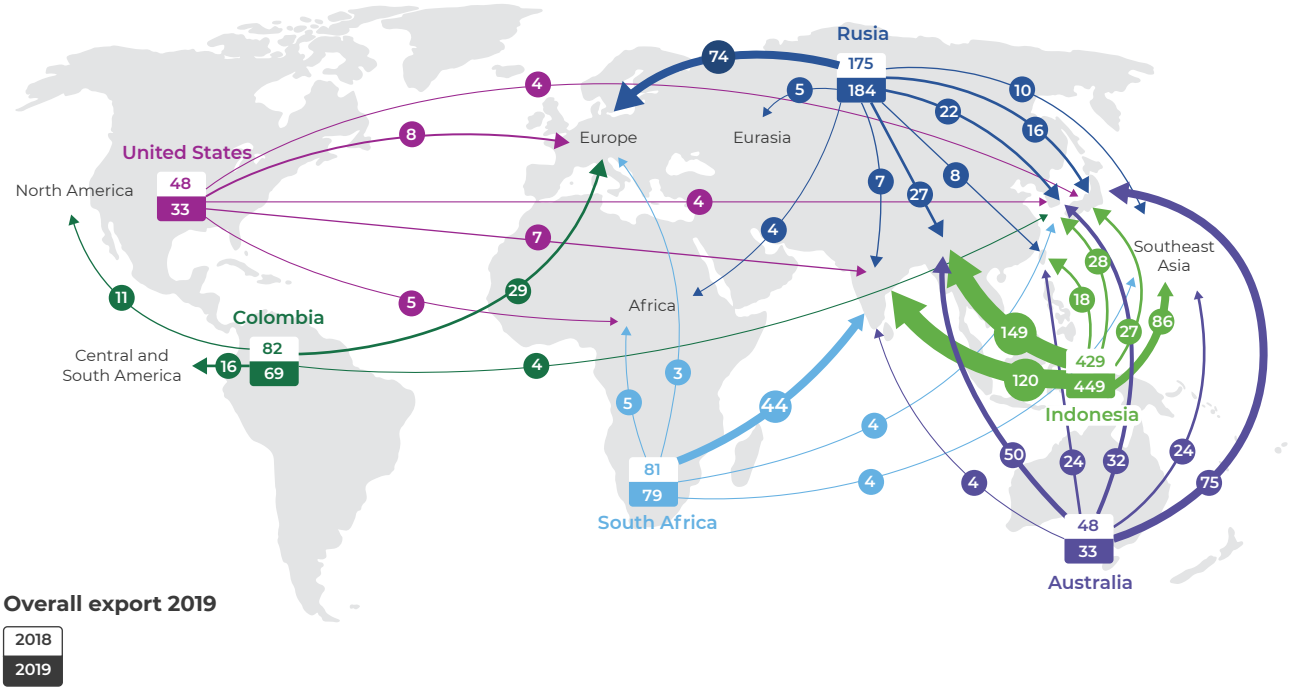


Figure 1. Global trade of thermal coal in 2019 (redrawn). Source: IEA (2020).

In the WEO 2021's STEPS, the Asia Pacific region's coal demand is estimated to slightly increase by 0.2% annually from 4,216 mtce in 2020 to 4,301 mtce in 2030, then decline by 1.2% annually to 3,375 mtce in 2050. It is significantly slower than the decline rate in the other regions, which averaged 1.9% yearly. Coal producers might conclude that the market for Indonesian coal would remain for the next two decades. However, the WEO projected that the share of coking and high calorific coal would increase in international trade while the share of low calorific coal would decrease. Indonesia, which mainly produces low calorific thermal coal, could lose market share and be overtaken by Russia as the second-largest exporter. Based on the WEO 2021 demand projection, IESR's analysis estimates that Indonesian coal export will decline from about 400 million to around 250 million tonnes between 2020 and 2050.

The coal demand decline would be much steeper under the SDS, whose most important change is the massive import cut from India and ASEAN countries. IESR's analysis projects a 40% and 75% cut of Indonesian coal export to around 240 million and 60 million tons in 2030 and 2050, respectively.

Domestic demand

The government's plan to reach net-zero by 2060 or sooner in the Long Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR) is used for the current commitment scenario's domestic demand. Subsequently, the MEMR and PLN plan to stop building new coal power plants by 2030. They intend to start phasing out old coal power plants from 2030, as stipulated in the RUPTL. This means that coal demand in the power sector would peak in 2030 at around 150 million tonnes, and rapidly decrease to around 85 million tonnes by 2040. Beyond 2040, the demand would decline to around 40 million tonnes in 2050 and become fully eliminated in 2060 or remain constant when the government utilizes CCUS technology. For the current commitment scenario, the CCUS pathway is assumed.

The expected decline in the power sector could be compensated by increased industrial consumption, though this might contradict the long-term net-zero commitment. Since no policy to stop industrial coal utilization exists, the current commitment scenario assumes that the current practice would continue.

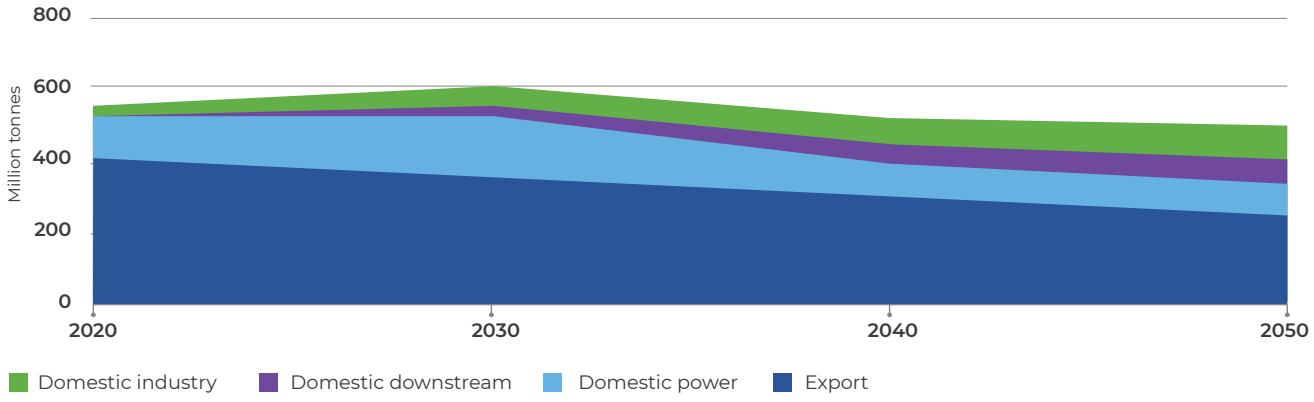
The industrial demand is projected by extrapolating the target set in MEMR's 2020-2024 Strategic Plan. The annual growth rate used for extrapolation follows sectoral GDP CAGR from 2010 to 2020. Additionally, there is demand from downstream coal industries, such as DME and methanol, already planned by the government.

For the accelerated phase-out scenario, the thermal coal demand for the power and industrial sector is obtained from IESR (2021). Coal power generation would be eliminated by 2045, and its use in industrial energy would be replaced by electricity or other low-carbon fuels, such as hydrogen. The downstream coal projects are also assumed to be abandoned because they are uneconomic and emit GHGs. Therefore, coal demand in the industrial sector would be mainly for processes such as steel making, which utilizes coking coal.

Overall demand

The overall demand for Indonesian coal would decline in the long term, as shown in Figure 2. Under the current commitment scenario, the total demand would slightly increase by about 10% until 2030, then decline to about 10% or lower than the current level. In this scenario, the demand would drop by 100 million tonnes between 2030-2050. Under the accelerated phase-out scenario, coal demand would decline by 20% in 2030, 60% in 2040, and almost 90% in 2050 compared to the current level. This would reduce the demand for Indonesian coal from about 550 million tonnes in 2020 to 440 million tonnes in 2030 and only around 70 million tonnes in 2050.

a. Demand projection for Indonesian coal in current commitment scenario



b. Demand projection for Indonesian coal in accelerated decline scenario

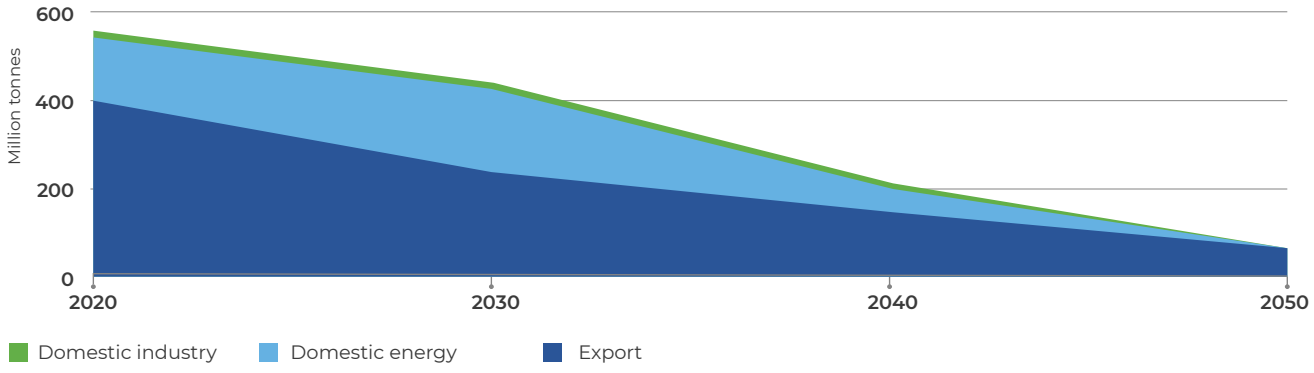


Figure 2. Demand projection for Indonesian coal in current commitment scenario (a) and accelerated phase-out scenario (b).

3. Impacted workers in coal value chain

This chapter discusses the potential implications of the long-term decline of Indonesian coal to related employment. It describes the various activities involved in the coal value chain and the current employment situation in the industry, including the worker characteristics. Additionally, the chapter discusses the potential impact of declining coal demand on workers.

3.1. Coal industry value chain

The value chain comprises the activities required to convert an input into an output or product. The coal value chain is the economic activities required to obtain the coal from the ground and deliver it to the user. It consists of four main activities: production, preparation or processing, transportation, and end-use (Tu, 2013).

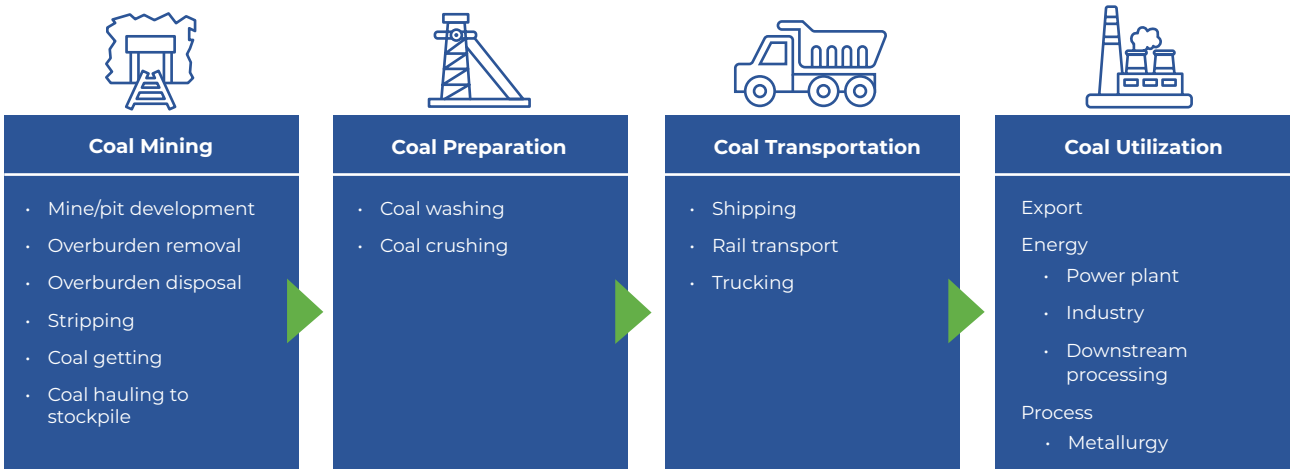


Figure 3. Illustration of value chain in coal production based on Tu (2013) and Rewu (2015).

Coal production

Coal production covers all activities involved in getting the coal out of the ground. There are different types of coal companies or license holders in Indonesia. These include the Coal Contract of Work (PKP2B), mining business license (IUP), special mining business license (IUPK), and community mining license (IPR). IUP holders could be divided into foreign, state-owned, and local IUPs, with varying mining areas, taxes, and royalties. The recent regulatory change eliminated the PKP2B contract model, requiring holders to convert their contracts into IUPK.

The coal companies' annual production varies from thousands to tens of millions of tonnes. Most PKP2B holders are large companies producing millions of tonnes yearly. In contrast, most local IUP holders produce less than a million tonnes annually (Direktorat Jenderal Mineral dan Batubara, 2021).

Coal mining or production activities could be divided into three main steps: overburden removal, coal getting and stockpiling, and transporting from the stockpile to the jetty (Rewu, 2015). The most costly and laborious step is overburden removal. In most cases, license holder mining companies differ from those conducting mining activities. Most mining activities are performed by contractors that own Mining Services Business License (IUJP). Additionally, some of the largest coal companies have subsidiaries operating as contractors.

Coal preparation

Coal may need treatment before shipping, depending on the buyer's requirements. The most common treatment performed in Indonesian mines is crushing the coal granules into smaller particles, whose size depends on the contract. The crushers are normally located in the stockpile area. Large coal producers usually have their crushers. Meanwhile smaller mines usually rent to smaller mines usually rent them from the larger ones.

Coal transportation

Coal is transported by ship, rail, or trucks depending on the mine site location, region, and destination. In Indonesia, the coal is mainly produced in Kalimantan and Sumatra, mostly for export destinations. However, the domestic consumers are mostly coal power plants located in Java and Sumatra. About 75% of the coal-generated electricity in 2020 was in Java, 13% in Sumatra, and less than 5% in Kalimantan (PLN, 2021). Therefore, coal is mostly transported by sea using barges and large vessels for inter-island and export destinations, respectively. Some companies specialize in shipping and are contracted by producers to ship their coal. However, sometimes large coal companies have barges to minimize delays.

Coal is transported to an inland terminal before entering the open sea barges or vessels. In Kalimantan, most inland transportation uses barges through the rivers, while dump trucks are mostly used in Sumatra[2]. The mining companies in South Sumatra also use railways to transport coal to the port, especially since the provincial government forbade the trucks from using public roads (Wijaya, 2019). Railways or barges are usually preferred due to lower costs and requiring fewer workers than trucking.

Coal utilization

Most of the coal produced is exported, with only about 20% used domestically (23% in 2020). In domestic use, 80% is used for power generation, while the remaining is utilized by pulp, paper, metallurgy, briquette, cement, textile, and fertilizer industries. Industrial consumption is mainly for energy sources, except for the metallurgy industry, which uses half of the coal for process input[3]. Metallurgical processes use coking coal, mostly imported because Indonesia mainly produces thermal coal.

[2] Oddang Rewu, personal communication.

[3] Estimated by Director of Coal Business Development, personal communication, August 24, 2021.

3.2. The current employment situation in the coal industry

Since contractors conduct most coal mining activities, about 80-90% of employment comes from mining services companies. These include contractors, consultants, suppliers, equipment rentals, surveyors, construction, transportation, environmental compliance, post-mining and reclamation, and health and safety. Only 10-20% of the employment comes from the coal mine owners. Coal companies use contractors mainly due to labor-management flexibility.

The MEMR data showed that the coal industry employed about 167,000 workers in 2020. This data accounted only for those working for the owners or contractors, whose permits were issued by the central government. Furthermore, the data excluded all jobs in non-mining activities, such as transportation and reclamation. The total employment in the coal industry is estimated to be around 250,000 workers.[4] This contributes to less than 0.2% of Indonesia's total employment, though it is more significant in the producing provinces. For instance, coal employment made up about 11% of total employment in East Kalimantan, 3% in South Sumatra, and 4% in North Kalimantan in 2020.

Table 1. Employment in coal companies whose permits were issued by the central government[5]. Source: 2012-2014 data from (MEMR, 2015), 2015-2020 data from Minerba One Data Indonesia.

	2012	2013	2014	2015	2016	2017	2018	2019	2020
PKP2B	21,694	22,066	21,004	17,387	16,652	14,912	13,501	14,566	14,414
IUJP	132,164	110,822	99,613	140,476	164,918	194,063	187,678	89,940	137,901
IUP					1,696	1,346	2,177	9,191	15,065
Total	153,858	132,888	120,617	157,863	183,266	210,321	203,356	113,697	167,380

* The number of employment in IUP is the total of employment in coal and mineral mining IUP

The labor needed to produce coal varies depending on the size of the mine site and the stripping ratio used. The ratio of the overburden removed to the coal obtained is called the stripping ratio, whose increase necessitates more labor. This happens during high coal prices when companies could afford to mine expensive deeper deposits that require a higher stripping ratio.

The MEMR data showed that the coal industry employment has fluctuated over the past decade due to unstable production rates and coal prices. The labor intensity also fluctuated, declining when coal prices dropped in the 2012-2015 and 2018-2019 periods and increasing when the prices boomed in late 2016 and 2020. The changing stripping ratio at different coal prices could explain this trend. At lower prices, companies tend to reduce the stripping ratio, requiring fewer workers per unit of coal produced, and vice versa.

Calculation based on the data in table 1 shows that the labor intensity in the coal industry over 2012-2020 period ranged from 0.4 to 0.65 jobs per 1,000 tonnes of coal produced. This was not the case in 2019, when coal employment plummeted to only 0.3 jobs per 1,000 tonnes. However, the numbers in each province or regency could differ from the nationally aggregated data. The labor intensity may differ in each company and region due to the variations in production capacity, site size, stripping ratio, location,

[4] Estimated by Director of Coal Business Development, personal communication, August 24, 2021. Owner companies whose permits were issued by the central government submit quarterly reports on the number of workers in their sites (including those from contractors) to the Ministry. Meanwhile those with permits issued by the regional government (IUP Daerah) report to their respective regional government. The Directorate of Coal Business Development estimated that this number only covers ⅔ of the total workers.

[5] The number of jobs in IUJP and IUP for mineral and coal mining is merged. While the exact proportion is not known, a large majority of those is coal mining. Thus, for this analysis, the contribution of mineral mining to IUJP and IUP employment is neglected.

and coal price. For instance, smaller mines usually use smaller equipment, which demands more workers. In comparison, Mongolia province is China's coal-mining region with the highest productivity at 0.17 jobs per 1,000 tonnes in 2015, while Jiangsu province is the least productive at 3 jobs per 1,000 tonnes.

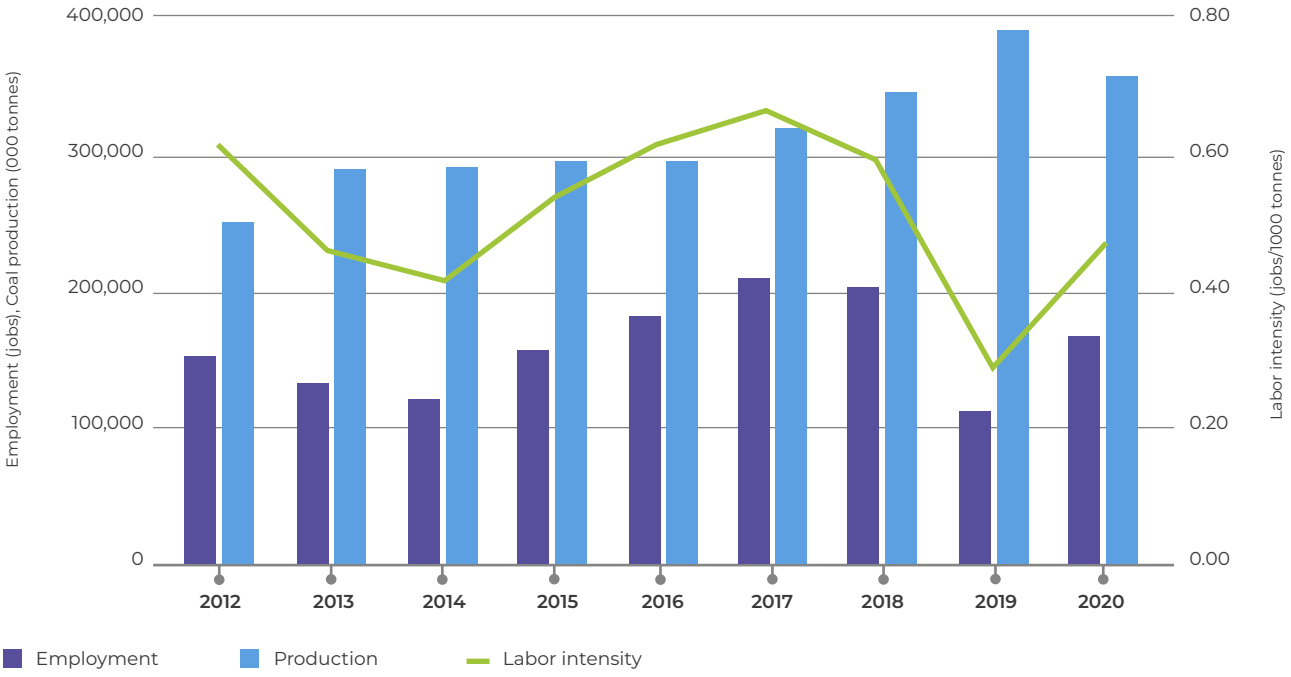


Figure 4. The employment in the coal industry, coal production, and labor intensity over the 2012-2020 period. The coal production number excludes production by local IUP to match the MEMR employment data.

There is no nationally aggregated data for coal workers' characteristics. Several publicly listed coal companies published their employment structure in their sustainability reports.[6] These companies generally employ mostly men below 50 and with high school or lower-level education. The employment characteristics data of these companies is provided in Appendix.

In most companies, workers aged more than 50 constitute only less than 10%, while 50% fall between 31-50 years old. However, young workers under 30 constitute a large proportion, between 15% and 37%. An exception is Bukit Asam, a state-owned company, where 41% of workers are over 50, 35% are under 30, and 25% are between 31 and 50. The structure is similar in contractor and owner companies. In owner companies, 45-71% of workers are high-school graduates or lower, 30-50% have a diploma or bachelor's degree, while less than 5% are post-graduate holders. Similarly, most contractors' workers are operators or mechanics with a high school education level.[7]

Some owner-company sustainability reports mention over 70% local employment. According to MEMR data, 66% of the total contractor workers in 2020 were registered as local. This high proportion of local employment is consistent with the Coal and Mineral Law. The law obliges mining service companies to prioritize local contractors and workers. Additionally, local regulations in several provinces or regencies require companies to employ a certain percentage of local people.

[6] Adaro Energy, Indika Energy, Kaltim Prima Coal, Harum Energy, Indo Tambangraya Megah, Bukit Asam, BUMA, and United Tractor. Some are holding companies, and the employment data often includes the subsidiaries. The first six companies are mainly site owners, and the last two are mining service companies.

[7] Executive Director of Aspindo, personal communication, September 21, 2021.

In contrast, Aprilia et al. (2019) stated that only about 40% of coal company workers in Berau regency, East Kalimantan, were local people, despite the Berau Regency Regulation No. 8/2018 requiring 80% local employment. The companies stated that they hired non-locals due to the lack of qualified and experienced local candidates. Moreover, not all "local employment" was hired from local people. People hired from other regions are often classified as local workers when they register and change their ID to the respective municipalities.

3.3. Potential of employment losses due to coal retirement

The two projection scenarios described in Section 2 show declining Indonesian coal demand and production. In the current commitment scenario, the production would slightly increase until 2030, then decline. In the accelerated phase-out scenario, the peak coal production occurs before 2030, and the decline occurs more rapidly. These scenarios could help estimate the employment loss in the coal industry.

It is hard to measure the extent of employment loss in the coal industry due to future demand uncertainty and the fluctuations in labor intensity. Gabriella & Simamora (2020) stated that labor intensity in Indonesian coal mining declined rapidly from 1998 to 2003. This trend was caused by increased production while employment stagnated due to improved productivity and automation. However, this is not observed in the recent 2012-2020 data, which showed that price fluctuation is influential to the labor intensity in the coal industry.

The World Bank predicted that coal prices would experience a long-term decline from an average of USD 140 per tonnes in 2021 to only USD 67.5 in 2030 and USD 55 in 2035 (World Bank Group, 2021). This decline would push the coal industry to improve efficiency and reduce the stripping ratio, decreasing the labor intensity in the long term.

The employment projection is assessed at various labor intensities: constant, 1% annual decline and 2.5% annual decline, as presented in Figure 5a (above). In the current commitment scenario, there would be 14,000-110,000 job losses by 2040 and 25,000-148,000 by 2050, depending on the labor intensity. Based on the accelerated phase-out scenario, the employment losses would reach 55,000-136,000 by 2030 and 227,000-252,000 by 2050. Figure 5b (below) shows the employment change percentages in the coal industry compared to 2020. A large decline in employment could be expected in most cases. Employment could decline by more than 30% due to declining coal prices in the current commitment scenario, where production is only slightly reduced.

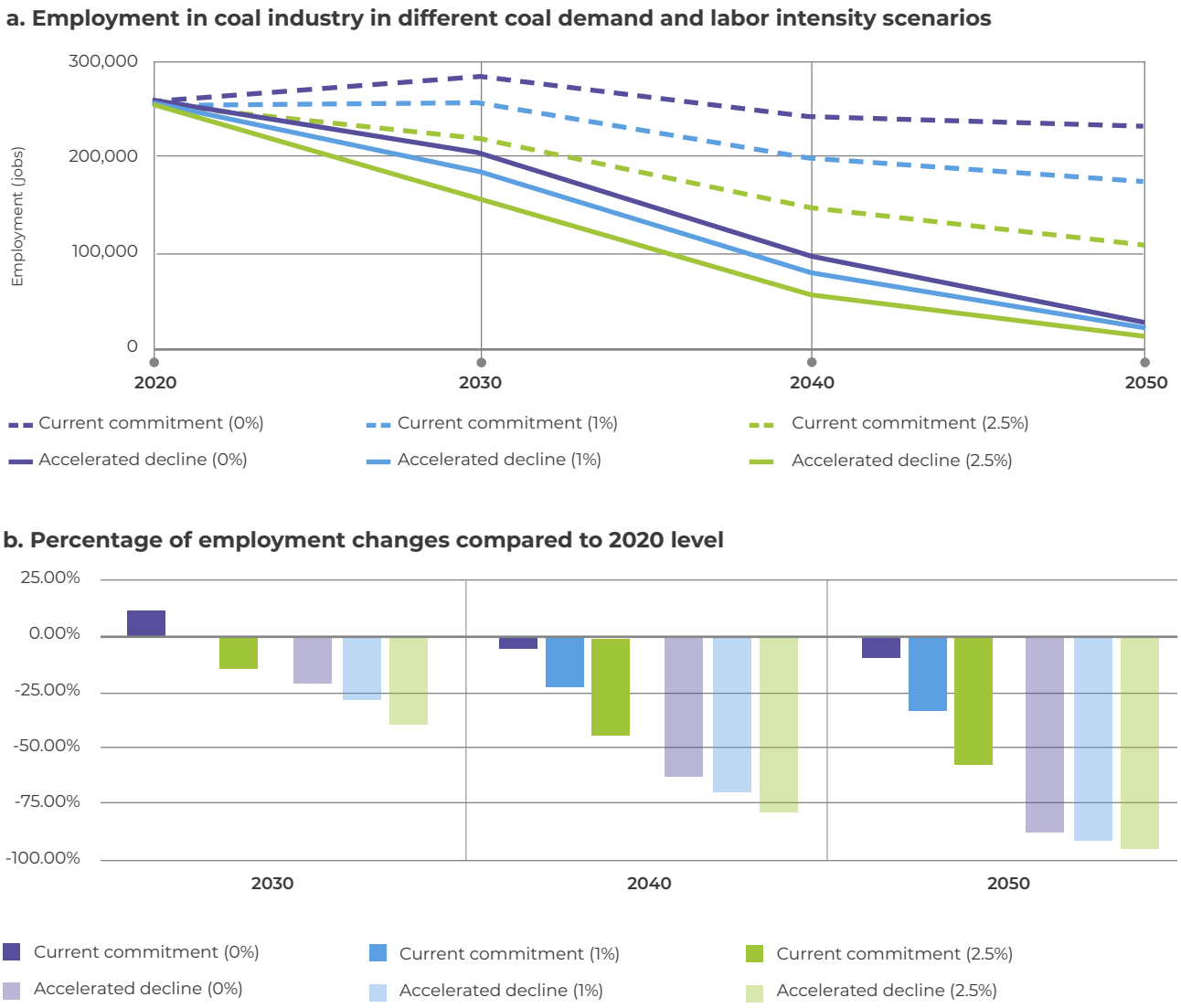


Figure 5. The employment (a) and the percentage of employment change (b) in the coal mining industry under the current commitment and accelerated phase-out scenarios at various labor intensities. The number in parentheses indicates the labor intensity annual decline.

Most workers are aged under 50, meaning they would still be productive and need to switch to new jobs when unemployment occurs after 2030. Those aged above 50 are most likely to retire by the 2030s. However, a study from Poland showed that most coal workers could not find employment in other sectors due to low education levels and higher salaries in the coal industry than in other sectors (Baran et al., 2020). Martyka and Majer (2010), as cited by Baran et al. (2020a), mentioned several problems that prohibit ex-coal workers from employment in other sectors. These include a demanding attitude and a lack of entrepreneurial drive, adaptability, and career vision.

In Indonesia, workers in mining and quarrying are paid 58% higher than the national average as of August 2021, with the difference more apparent for the high-educated workers. The mining and quarry workers also have low education levels, with 60% not graduating from high school. Few other sectors have similar education characteristics, including manufacturing, water supply, construction, and hospitality, though they are paid the least.

Coal workers are largely unaware of the potential unemployment due to global and national climate policies. There is no national policy to mitigate the employment impact of coal phase-out on workers. Similarly, companies lack a preparation program for workers to shift to other sectors.

3.4. Managing the impact on coal workers

Short-term and long-term strategies are needed to manage the impact of coal decline on workers. The main issues in short to medium-term include providing immediate support to and reallocating the affected coal workers. Moreover, long-term economic diversification is necessary to provide sustainable employment opportunities (Wuppertal Institut, 2022). This part focuses on the short-term measures, while the latter is discussed in the next section.

Reallocating the affected coal workers could comprise measures from the labor supply and demand side. From the labor supply side, workers with transferable skills such as management, administration, marketing, electrician, or mechanics could be retrained to adapt to new fields. Reskilling is also important for workers with specific skills that might be less relevant to other sectors, such as heavy machinery operators. However, this should be carefully crafted to fit future job requirements. On the demand side, additional jobs could be created by promoting local entrepreneurship. Providing better infrastructure to surrounding areas could connect workers to more job opportunities without relocating. Additionally, workers could be moved to alternative roles within the same company. They could move to work on coal phase-out-related jobs such as mine site rehabilitation or renewable energy installation as a short-term replacement (Just Transition Initiative, 2021; Wuppertal Institute, 2022).

Immediate reallocation might not be feasible in the case of accelerated decline. Therefore, short-term support should be provided for the affected workers, especially the more vulnerable ones. Bridging programs for early retirement could be an option for older workers, while internship programs might be ideal for younger workers. Additionally, sufficient unemployment benefits and social safety net might minimize the immediate impact on the affected workers (Gabriella & Simamora, 2020; Wuppertal Institut, 2022).

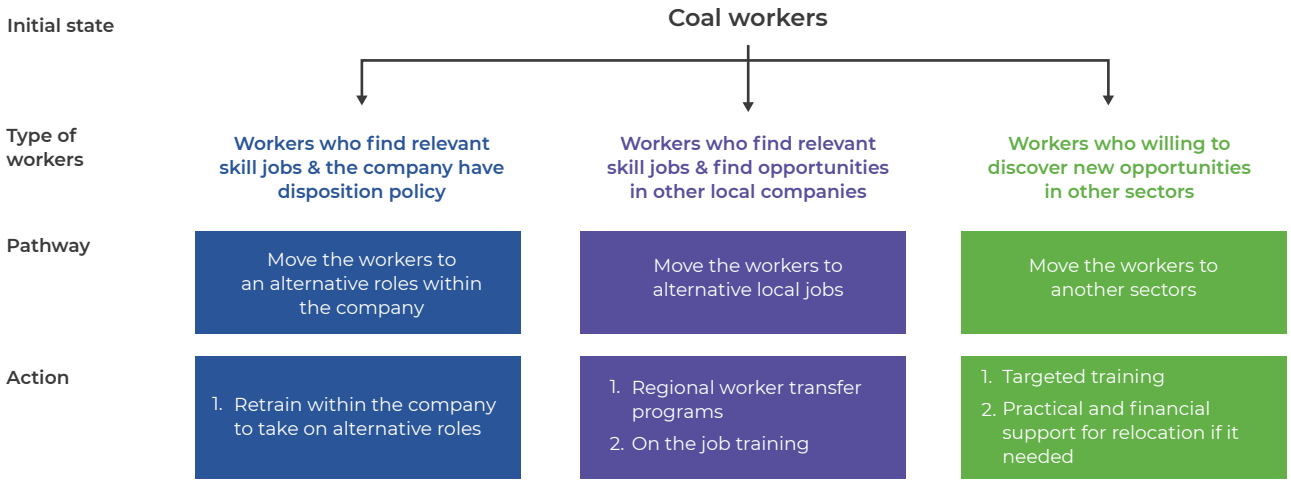


Figure 6. Coal worker transition strategies
(Adapted from: Wuppertal Institut, 2022)

4. Opportunities for economic transformation in coal dependent regions

4.1. Coal contribution to national and local economies

Coal in the national economy

Aside from its role as an energy source, coal is also a commodity that contributes to the national economy. As a major export commodity, it helped reduce the current account deficit, as shown in Figure 7. In 2021, coal contributed USD 26.5 billion of export value, or 12% of non-oil and gas export, second only to CPO at USD 28.5 billion.

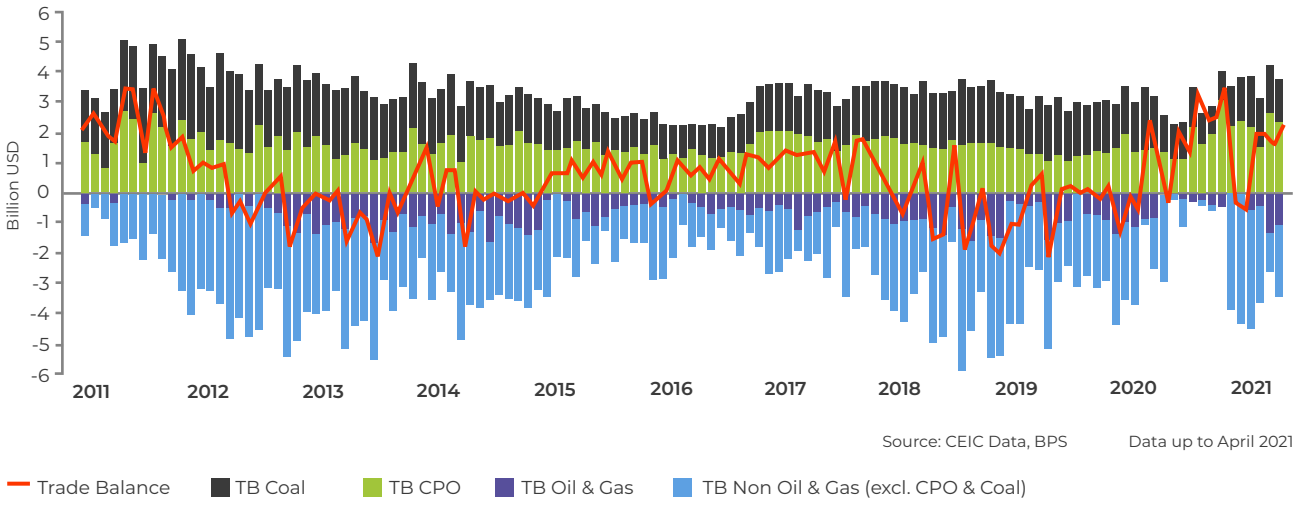


Figure 7. Indonesia's trade balance, including the contribution of the coal sector in billions of USD (Prawiraatmadja, 2021)

Coal contributes to state revenue through related industrial taxes and non-tax state revenues (PNBP), as stated in Government Regulation 81/2019. The non-tax state revenue comprises mining area information system services fees, fixed fees or land rent, and production fees or royalties. This revenue depends on coal sales, which are influenced by global market prices. State revenues from coal production fees or royalties have declined in the last few years, as shown in Table 2.

Table 2. Coal production fees / royalties in total state revenue (MoF, 2021)

(in billion rupiahs)	2017	2018	2019	2020
Mineral & Coal Mining Revenue	23,763.17	30,313.67	26,343.69	21,178.99
Coal Mining Production Contribution/ Royalty Income	23,247.33	21,854.96	19,718.73	12,558.02
Non-Tax State Revenue from Natural Resources (PNBP SDA)	111,132.04	180,592.65	154,895.29	97,225.07
Non Tax State Revenue (PNBP)	311,216.25	409,320.24	408,994.35	343,814.21
Total State Revenue	1,666,375.91	1,943,674.88	1,960,633.58	1,647,783.34
% Coal mining royalty compare to PNBP SDA	20.92%	12.10%	12.73%	12.92%
% Coal mining royalty compare tp PNBP	7.47%	5.34%	4.82%	3.65%
% Coal mining royalty compare to Total State Revenue	1.40%	1.12%	1.01%	0.76%

For the economy, coal and lignite mining contributed 401.3 trillion rupiahs or 2.7% to total GDP in 2018, as shown in Table 3. These numbers cover the coal mining sectors while excluding the other related industries.

Table 3. Coal and lignite mining contribution in GDP (BPS-Statistics Indonesia, 2021)

(in billion rupiahs)	2016	2017	2018	2019*	2020*
Coal and Lignite Mining	231,697.8	323,364.5	401,276.9	368,890.5	283,194.7
Total Gross Domestic Product	12,401,728.5	13,589,825.7	14,838,756.0	15,832,535.4	15,434,151.8
% Coal and Lignite Mining contribution to GDP	1.87%	2.38%	2.70%	2.33%	1.83%

*preliminary figures

Wibisono (2015) analyzed the coal sector's economic impact, including employment, using econometrics and data on several provinces from 2003 to 2013. The results showed that coal production positively but insignificantly impacts employment. A 10% increase in production increases the employment rate by only 0.79%. This shows that Indonesia's coal industry is highly capital intensive and only absorbs a few workers when the company increases its production. Therefore, the production does not create many jobs, and the resulting welfare is not well distributed to all citizens (Wibisono, 2015).

Coal in the local economy

Coal contributes to the local government revenues, impacting the local economy. In this case, 80% of the land-rent and royalties paid as PNBP are reallocated as Revenue Sharing Funds (DBH) to the producing regions, as stated in Government Regulation 55/2005 (DGFB MoF, 2017). For the land rent, 16% of the PNBP goes to the provincial government and 64% to the producing city or regency. Similarly, 16% of the royalty is allocated to the provincial government, 32% to the producing city or regency, and 32% to the surrounding cities or regencies.

In Indonesia, most coal resources and reserves are located on the islands of Sumatra and Kalimantan. Each basin has different characteristics of coal quality. Kutai, Tarakan, and Barito basins in Eastern Kalimantan have medium-quality coal, with a calorific value between 5100-6100 kcal/kg. The Central and South Sumatra basins have low-quality coal reserves, with a calorific value of <5100 kcal/kg (Arinaldo & Adiatma, 2019). Table 4 shows coal production by province in the last two years. Most coal is produced from East Kalimantan, South Kalimantan, South Sumatra, North Kalimantan, and Central Kalimantan.

Table 4. Coal production by province in 2019 and 2020 (DGMC MEMR, 2021)

Indonesia provincial level coal production in 2019

No	Province	Production (tonnes)	%
1	East Kalimantan	296,969,242	48.20%
2	South Kalimantan	196,423,446	31.88%
3	South Sumatra	56,536,852	9.18%
4	North Kalimantan	21,322,902	3.46%
5	Central Kalimantan	20,635,324	3.35%
6	Jambi	12,837,846	2.08%
7	Aceh	7,722,623	1.25%
8	Bengkulu	2,399,361	0.39%
9	West Sumatra	696,531	0.11%
10	Riau	590,892	0.10%
11	South Sulawesi	4,575	0.00%
	Grand Total	**616,139,594**	

Indonesia provincial level coal production in 2020

No	Province	Production (tonnes)	%
1	East Kalimantan	258,448,584	47.87%
2	South Kalimantan	178,448,579	31.82%
3	South Sumatra	52,365,318	9.34%
4	North Kalimantan	19,481,102	3.47%
5	Central Kalimantan	17,608,915	3.14%
6	Jambi	10,744,114	1.92%
7	Aceh	8,991,921	1.60%
8	Bengkulu	2,842,276	0.51%
9	Riau	1,629,242	0.29%
10	West Sumatra	145,478	0.03%
11	Southeast Sulawesi	34,610	0.01%
12	South Sulawesi	1,764	0.00%
	Grand Total	**560,741,905**	

Coal mining contributes greatly to the producing provinces' Gross Regional Domestic Product (GRDP) than the national GDP. Figure 8. shows that the contribution of the coal and lignite mining sector in East Kalimantan, South Kalimantan, and North Kalimantan provinces exceeded 15% of each GRDP. This value does not include those from other related industries. The contribution of coal mining to GRDP is often higher. For instance, over the past decade, it contributed over 70% of Paser Regency's GRDP (BPS Kabupaten Paser, 2022).

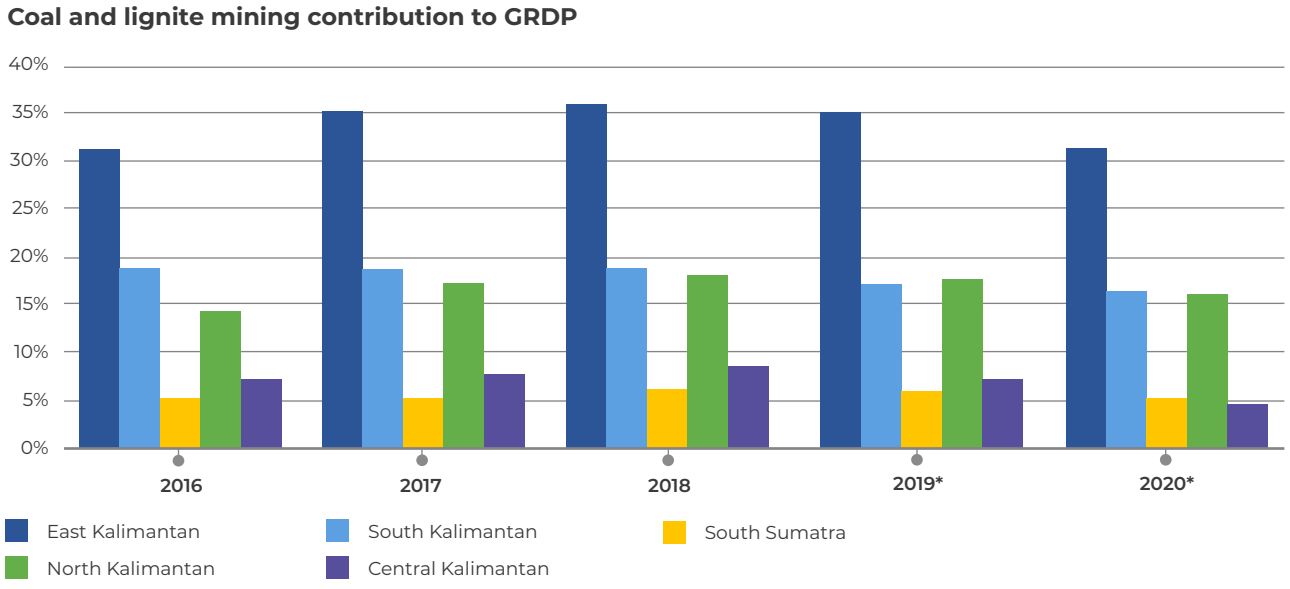


Figure 8. Coal and lignite mining contribution in GRDP (Provincial BPS-Statistics Indonesia, 2021)

Small-scale illegal or unlicensed mining activities also exists in Indonesia. As of semester II-2019, there were 55 unlicensed mining activity points in the Mining Business Permit (IUP) of the Tanjung Enim Mining Unit managed by PTBA. Due to its traditional practices, this shadow economy could cause environmental damage and mining accidents. Although informal and illegal mines do not pay taxes and royalties to the state, they still supports the local economy.

A study in South Kalimantan found that coal mining produced little value-added per output than other economic sectors, created few employments, and had high economic leakage. The economic benefits were also not distributed equally. A higher share of the value-added in coal mining went to capital owners. Coal mining also tended to generate more income for the already higher-income households (Fatah, 2008). Furthermore, another study in East Kalimantan stated that coal mining benefited the capital owner more than the workers. More benefits were enjoyed by the urban than the rural households (Hilmawan et al., 2016). Additionally, the mining industry has a low employment intensity, meaning that coal mine closures would improve East Kalimantan's average employment multiplier.

Box 1. Importance of coal mining in East Kalimantan economy

East Kalimantan province has the largest coal production. In recent years, the coal and lignite mining sector has contributed more than 30% of the province's GRDP, which shows a large dependence. Therefore, it is important to consider the role of coal in the local context.

The local quotient (LQ) index calculated from GRDP data showed a region or province's relative specialization in certain industries. The results showed that East Kalimantan's coal and lignite mining LQ index was 15 in 2020. Other sector LQ index calculation results are shown in Appendix. An LQ index higher than 1 means the sector in the region is superior to the sector's condition in other regions. Few other sub-sectors in East Kalimantan have an LQ index higher than 1. These include coal processing and refinery, oil and gas lifting, and other mining. Other sub-sectors are water, sea, aviation transportation, warehouse, forestry, and chemical industry. However, they are much lower than coal mining. This indicates that East Kalimantan's economy is highly dominated by coal mining, which it exports to other regions in Indonesia.

Analysis using Input-Output (I-O) data showed the interaction between sectors in the province. Calculations using I-O data from East Kalimantan in 2016 showed that the coefficient value for backward linkage is 0.97, while forward linkage is 1.29 for the coal and lignite mining sector, as shown in Figure 9. Other sector calculation results are shown in the Appendix. A backward linkage value slightly lower than one indicates that an increase in this sector only slightly increases the demand for its input sectors. In comparison, the forward linkage value greater than one indicates that an increase in this sector could increase the demand for other sectors using its output.

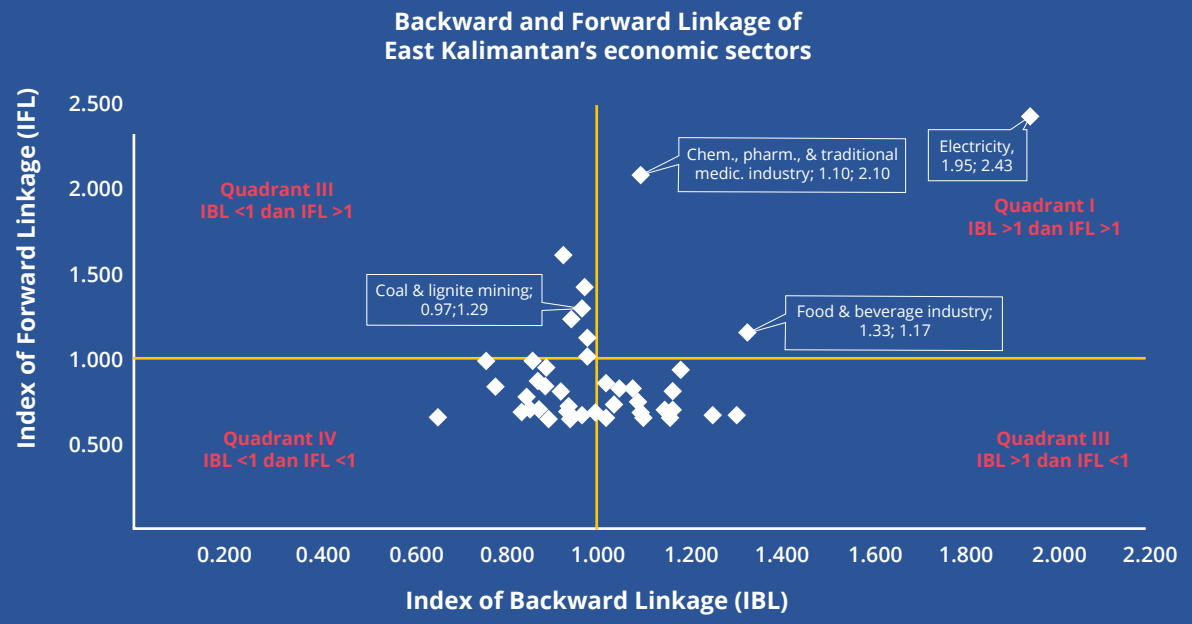


Figure 9. Backward and Forward Linkage of East Kalimantan's economic sectors

The output multiplier from the IO analysis shows other sectors' dependence. For instance, a 5% decrease in the final output of coal and lignite mining sector in East Kalimantan reduces the final output of the overall sector by 1.9%. The sectors with the most reduction are mining and other quarrying by 2.43%, company services by 2.4%, river and lake transportation and crossings by 2.07%, land transportation by 2.03%, and financial support services by 1.85%.

4.2. Opportunities for economic diversification and reducing coal dependency

The coal sector contributes significantly to the local economy in the producing regions, but the impact on employment is less significant. Natural resource extraction also causes the resource curse or Dutch disease, where the other non-extraction sectors fail to grow in the area (Humphreys et al., 2007). Since wealth is developed by one major sector in the local economy, developing a diversified and skilled workforce for higher economic growth has not been prioritized in the coal regions. The development of the other sectors is difficult, even as the natural sector started to decline. Therefore, coal regions need economic diversification because the natural resource extraction by coal industries failed to benefit the affected community. Economic diversification could stabilize growth and development and reduces volatility impacts on the economy (OECD/WTO, 2019).

The UN 2030 Agenda defines economic transformation as "fundamental changes in the economy that raise the overall productivity level while ensuring adequate quantity and quality of employment, equitable distribution of income and wealth, access to quality public services, and protection of the environment" (UN SDG, 2020, p. 6). The transformation should not prioritize economic growth over social and environmental aspects. For instance, it aims to raise productivity, diversify the economy, and create decent jobs. The transformation also ensures that economic growth does not increase environmental degradation. To achieve this, the transformation uses a sustainable approach, such as a circular economy and implementation of proper clean technologies. Referring to social benefits, economic growth protects and promotes access to public services and resources, vertical and horizontal equalities,[8] and human rights. The transformation from a coal-intensive economy results in income reduction and employment in coal regions. However, it also helps reduce pollution and inequality and combat climate change (Vögele et al., 2022). For this reason, Indonesia could gain multi-benefits from the transitioning from a coal-intensive into a greener, more resilient, diversified economy.

Indonesia could gain insights from how other coal regions managed their economic transformation. As large producers, China, Germany, and Canada, have experienced coal transitions in the past and were selected as examples in this study. In China, Jiazuo and Wuhai cities survived a coal industry downturn in the 1990s through different pathways. Another example is the transformation of the Ruhr and Saarland region when Germany shifted from a major coal consumer to renewable energy. Similarly, Canada's federal and provincial governments created policies to support workers and economic diversification for coal mine closures due to coal-phase out policies in several regions. The lessons learned from precedence counties' economic diversification are discussed as follows:

• China

The economic diversification due to the coal downturn in Jiaozuo, China, could be a lesson in avoiding the resource curse. After one century of coal exploitation, Jiaozuo experienced the resource curse stage. This was indicated by the slowing down of the economic growth starting from 2011 (Zhao et al., 2021). Jiaozuo's annual growth rate of GDP per capita in 1991-1997 and 2001-2010 remained high at 10% – 45%. However, the annual growth rate of GDP started to slack off below 10%, and Jiaozuo City suffered a resource curse in the 2013-2018 period. To solve the coal exhaustion problem, the city started transforming from coal-intensive into a diversified economy dominated by energy, chemical industry, metallurgy, building materials, and tourism in 1996. Five sectors of industries added value of more than 10 billion Yuan to Jiaozuo. These included the manufacture of metal and non-metal products, general and special-purpose machinery, raw

[8] Vertical (in)equality differentiates individuals and groups by status, while horizontal (in)equality refers to power distribution between peers (Fiske & Bai, 2020).

chemicals and chemical products, food processing and manufacturing, and metal smelting and processing. Moreover, the government utilized the city's rich tourism resources and prime location and started promoting and developing its tourism and services sector. In 2018, Jiaozuo diversified its GDP composition, with more than 90% coming from secondary and tertiary industries and below 10% from primary industries.

Wuhai City transformed its economy gradually from a coal-intensive economy to a heavy chemical industry and later to a diversified economy, including tourism (Yang, 2020). In the first transformation in 1998, the city diversified its economy from coal mining into the heavy chemical industry. The heavy chemical industry development had a competitive advantage due to the low-cost energy coming from coal. In 2008, Wuhai was developed into a coal downstream industry base to mitigate the skyrocketed oil and gas. The coal industry's value chain was well developed, though air pollution became a major issue in 2013, resulting in coal power plants and mine closures. Moreover, Wuhai developed sustainable mining industries and expanded the existing ones to high-tech and clean energy industries, such as advanced materials and hydrogen. The city developed the tourism industry in recent years as environmental conditions improved. The government boosted the tourism through a conservation project and new tourist destinations to attract tourists. In 2019, the share of the service industry in GDP escalated to 37% from 27% in 2010. Furthermore, Wuhai received 3.5 million people in 2018 and is increasing with a 25.8% annual growth rate of tourism revenue, reaching 1.1 billion USD.

• Germany

Germany has transitioned coal mining workers in the Ruhr area and Saarland from 665,000 in 1957 to below 5,000 in 2017 without causing severe unemployment (Oei et al., 2020). The Saarland example showed that attracting investment in new sectors is easier when related industries exist in the surrounding area. In Saarland's case, the presence of car manufacturers in proximity attracted investment from automotive suppliers. However, the transformation developed a new dependency on the automotive industry due to a lack of diversity. In contrast, the Ruhr area transformation adopted a more inclusive approach with support schemes distributed to various sectors. This resulted in a diversified industry structure expected to be more resilient.

Coal mine closures in Germany from 1975 to 2017 negatively impacted the economy but made entrepreneurship and innovation flourish, especially in start-ups. The closures also increased job growth in information technology (IT) as well as research and development (R&D) sectors (Janssen et al., n.d.). For instance, the Ruhr area has transitioned the workers from mining industries, including coal, into added-value industries towards a knowledge-based economy (Gabriella & Simamora, 2020). It has successfully increased the gross value added from 61.4 million euros in 1980 to 142.4 million euros in 2014 (Dahlbeck et al., 2022).

• Canada

Canada's strategies for coal phase-out in 2030 could be lessons for Indonesia. The accelerated coal phase-out target has several considerations, including job shifting, community and regional economic development, and capital allocation (Brown & Jeyakumar, 2022). Moreover, the Government of Canada commissioned the Task Force to provide knowledge, options, and recommendations to the Minister of Environment and Climate Change on mitigating the accelerated coal phase-out impact on the workers. Though the transformation to clean energy threatens job losses, it creates new opportunities estimated to add 208,700 jobs in 2030. Coal mine reclamation could also extend the work of about 20-65% of the workers. Furthermore, diversification and

industrial strategizing could strengthen the local economy by creating new revenue streams and local employment opportunities. Net-zero commitments also enhance the private investment in sustainable business to reach a net-zero emissions investment portfolio.

4.3. Enabling conditions for successful economic transformation

It is important to identify the enabling factors from the previous experiences when establishing the economic transformation plan. Transition experiences from the coal regions in China, Germany, and Canada could provide insights into the enabling conditions of a successful transformation. Table 5 summarizes the identified enabling factors from the three countries to transform their coal-dependent economies into more diversified and resilient ones.

Table 5. Enabling conditions for economic transformation identified in the experiences in other coal regions described in 4.2.

Aspects	Enabling conditions	Examples in literature
Government interventions	Central government actions	• The State Council in China established a compensation mechanism of resource development to aid declining industries and intensify financial general and special transfer payments at the end of 2007. It also approved the "Master Plan of Jiaozuo City" to develop Jiaozuo and other 16 cities in parallel in July 2017 (Zhao et al., 2021). • In 2018, the Government of Canada established a Task Force on Just Transition for Canadian Coal Power Workers and Communities to consult the government on achieving just transition for those impacted by the coal phase-out (Government of Canada, 2018). However, most of its recommendations have not been adopted.
	Regional and local government participations	• The governments of Henan Province and Jiaozuo City made policies that promoted the city's transformation. Enterprises have improved their capabilities through restructuring and structural adjustment (Zhao et al., 2021). • Alberta provincial government, in particular, made earlier coal phase-out plans and managed to better equip the province with the necessary protection policies for impacted communities than other provinces (Brown & Jeyakumar, 2022). • Saarland attracted Ford Motor Company through subsidies, premiums, and tax concessions (Oei et al., 2020).
	Policies	• The Ruhr area was supported by structural policy to make long-term structural changes with forward-looking objectives (Dahlbeck et al., 2022).
Transformation approaches	Polycentric approach	• City, regional, and national governments and institutions could cooperate in the complexity of the challenges of worker transition (Oei et al., 2020). • The government introduced "Action Program Ruhr" to develop strategies through participation and dialogue (Gabriella & Simamora, 2020).
	Gradual economic transformation	• Wuhai city gradually transformed its coal-intensive economy into a diversified economy (Yang, 2020). • A diversified economy is achieved through a long process like in the Ruhr area. A quick replacement by another big industry is a faster pathway, but could fall into another dependency as shown in the Saarland example (Oei et al., 2020).

Aspects	Enabling conditions	Examples in literature
Transformation approaches	Institution establishment	• A local institution is established in the Ruhr area to coordinate allocation of national funding (Oei et al., 2020). • A task force was developed to provide knowledge, options, and recommendations to the government (Government of Canada, 2018).
Community revitalization	Workers facilitation	• Facilitate retraining and socialize the coal phase-out plans to the workers (Oei et al., 2020). • In 2019, $150 million was allocated for infrastructure investments in impacted communities. The respective provincial governments also prepared financial assistance and training for impacted workers and funds for economic diversification programs (Government of Canada, 2018). • In 2018, the Government of Alberta instituted Coal Workforce Transition Program to provide options for financial assistance for re-employment, retirement, relocation, and education for affected workers (Brown & Jeyakumar, 2022).
	Local development	• The government improved infrastructure, education, research facilities, and soft location factors (Oei et al., 2020). • Education and research centers increase attractiveness for companies and citizens, and create competitive and resilient structures for the companies to stay and the new ones to come (Oei et al., 2020).
	Financing availability	• The Canadian federal government dedicated $35 million over five years to support the economic diversification in the coal regions through capacity building, entrepreneurship, start-up expansion, and supply chain development (Government of Canada, 2018). • The Government of Alberta allocated $5 million to run projects in the region (Brown & Jeyakumar, 2022).
Comparative advantages		• Jiaozuo is located in the "semi-hour economic circle" of Zhengzhou, the capital city of Henan province, with convenient transportation (Zhao et al., 2021). • People tend to stay in places with good and soft location factors, including cultural and leisure time possibilities and environmental issues (Oei et al., 2020). • Saarland attracted new industries since it has related industries within its surroundings (Oei et al., 2020). • The Ruhr area became Germany's "industrial heart" for the longest period in the 20th century (Oei et al., 2020).

The four aspects found essential in the economic transformation are governance interventions, transformation approaches, community revitalization, and comparative advantages. The first aspect highlights the role of central and local governments in establishing long-term strategies, structural policies, and regulations. This helps promote transformation, attract investment in non-coal sectors, and support impacted populations. The second aspect emphasizes the gradual and participatory approach to transformation processes. The third aspect focuses on what to do for the impacted communities or society, such as support for workers, local infrastructure, and financing. The fourth aspect views coal regions' characteristics, such as location, natural capital, and proximity to economic centers, creating comparative advantages that influence the suitable transformation pathway. Gabriella & Simamora (2020) also included the creation of a positive investment climate in renewable energy and non-coal sectors to attract new investment to the regions as an important enabler.

4.4. Planning for structural transformation towards a diverse and resilient economy in coal regions

The experiences of coal regions transition in China and Germany show gradual economic structure transformation from strengthening of the industrial sector to development of the service sector. The service sectors developed were the nature tourism and the knowledge-based economy in China and Germany, respectively. The Clark-Fisher model in Figure 10, suggests that economic development follows an employment shift. The shift occurs from the primary (agriculture and mining) sectors in the preindustrial economy to the secondary (manufacturing and construction) sectors in the industrial economy. The development later shifts to tertiary (services) or quaternary (information and communication) sectors in the post-industrial economy. Although the model was based on the experience of the UK, the general pattern has also occurred in other countries. The share of employment and nominal value-added decrease in agriculture, increase in service and create a hump shape in manufacturing as GDP increases (Herrendorf et al., 2014).

This gradual development model could serve as a template for the economic transformation pathway in the Indonesian coal regions. In the early phase, the economic transformation strategy could focus on strengthening the manufacturing industry while modernizing and improving the practices in the primary sector. However, as the Clark-Fisher model suggests, the importance of secondary sectors will decline as the economy grows and be outgrown by the tertiary and quaternary sectors. This necessitates preparing for the development of the services sector for the long-term transformation.

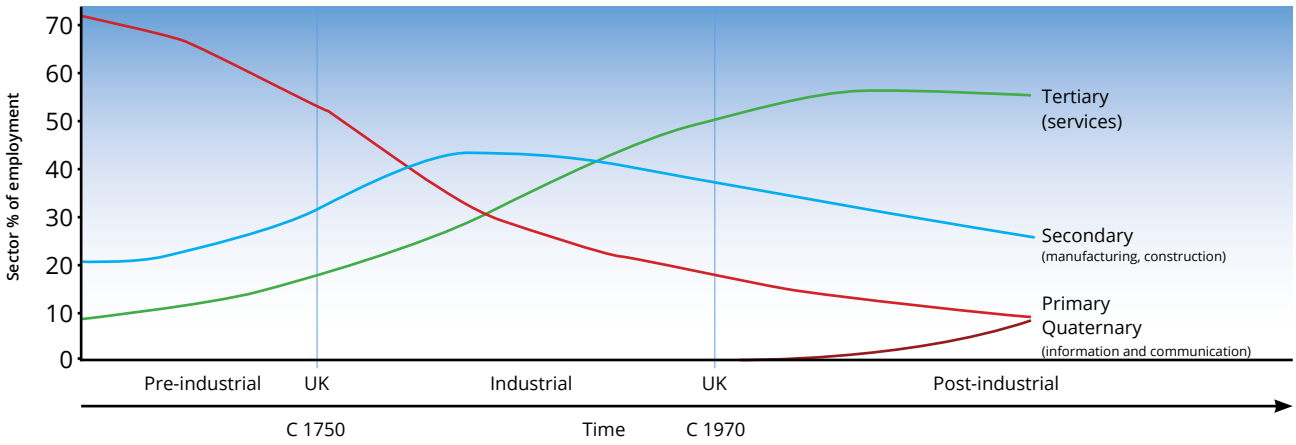


Figure 10. Clark-Fisher model (Source: (Study Rocket, n.d.))

• Primary sector modernization and sustainability improvement

The agriculture and mining sectors are the dominant economic activities in the coal regions and is expected to remain so in the short future. The extractive economy often degrades natural landscapes and human capital needed for the later development of the service-based economy. Therefore, improvement in the governance, technologies, and practices of the agriculture and extractive industry should minimize the negative impacts and increase the sector's productivity.

• Secondary sectors strengthening

As shown in Jiaozuo and Wuhai in China (Yang, 2020; Zhao et al., 2021) and the Ruhr Area and Saarland in Germany (Oei et al., 2020), the manufacturing industry development was the first stage in the economic transformation process. One way to plan for economic diversification is to expand the sectors with high importance in the existing economic structure. In the main coal provinces of East Kalimantan and South Sumatra, manufacturing industries such as F&B, chemical, and pulp and paper, were key sectors with high multiplier effects,[9] as shown in table 6. Therefore, the provinces could reallocate their resources to strengthen these key industries.

Table 6. Key sectors and output multiplier indexes in East Kalimantan and South Sumatera. Source: (BPS Provinsi Kalimantan Timur, 2021; BPS Provinsi Sumatera Selatan, 2021)

	East Kalimantan	South Sumatera
Key sectors (Output multiplier index)	1. Electricity (2.95) 2. F&B industry (2.02) 3. Chemical, pharmacy, and traditional medicine (1.67)	1. Electricity (2.96) 2. F&B industry (1.89) 3. Pulp & paper (1.81) 4. Chemical, pharmacy, and traditional medicine (1.64) 5. Coal mining (1.64) 6. Construction (1.63)

The provinces could also develop the downstream industry of their main export commodities to increase the local added value and employment. In addition, most business units in Indonesia come from small and medium enterprises (SMEs). Therefore, the manufacturing and processing SMEs could be scaled up through corporatization, capacity building, and access financing to strengthen the secondary sector in the coal regions.

• Preparation for tertiary and quaternary sectors development

Wuhai developed the tourism industry in its region at a later economic transformation phase by utilizing its natural landscape. In the Ruhr area, the knowledge economy gained importance in the later phase of its transformation. However, preparations must be initiated for these to happen. For instance, transportation infrastructure is essential for tourism industry development. It is also necessary to restore the natural landscapes degraded by mining activities to attract tourists, as seen in Wuhai and Ruhr areas. Additionally, improving human resources, such as education and health, is important in developing the service sector, especially the quaternary or knowledge-based sector. Educational institutions and healthcare systems should be scaled up and improved to prepare the human capital for the service economy. These aspects are often lacking and should be prepared to enable the long-term sustainability of economic development in coal regions.

[9] Key sectors have an index of backward linkages (IBL) and forwarding linkages (IFL) higher than 1, indicating that the sector has an important role in the region's economy. The output multiplier index is a parameter that indicates the total increase of economic output to satisfy each unit of final demand increase in the sector. Key sectors with the highest multiplier are suggested to be prioritized to generate the most gain.

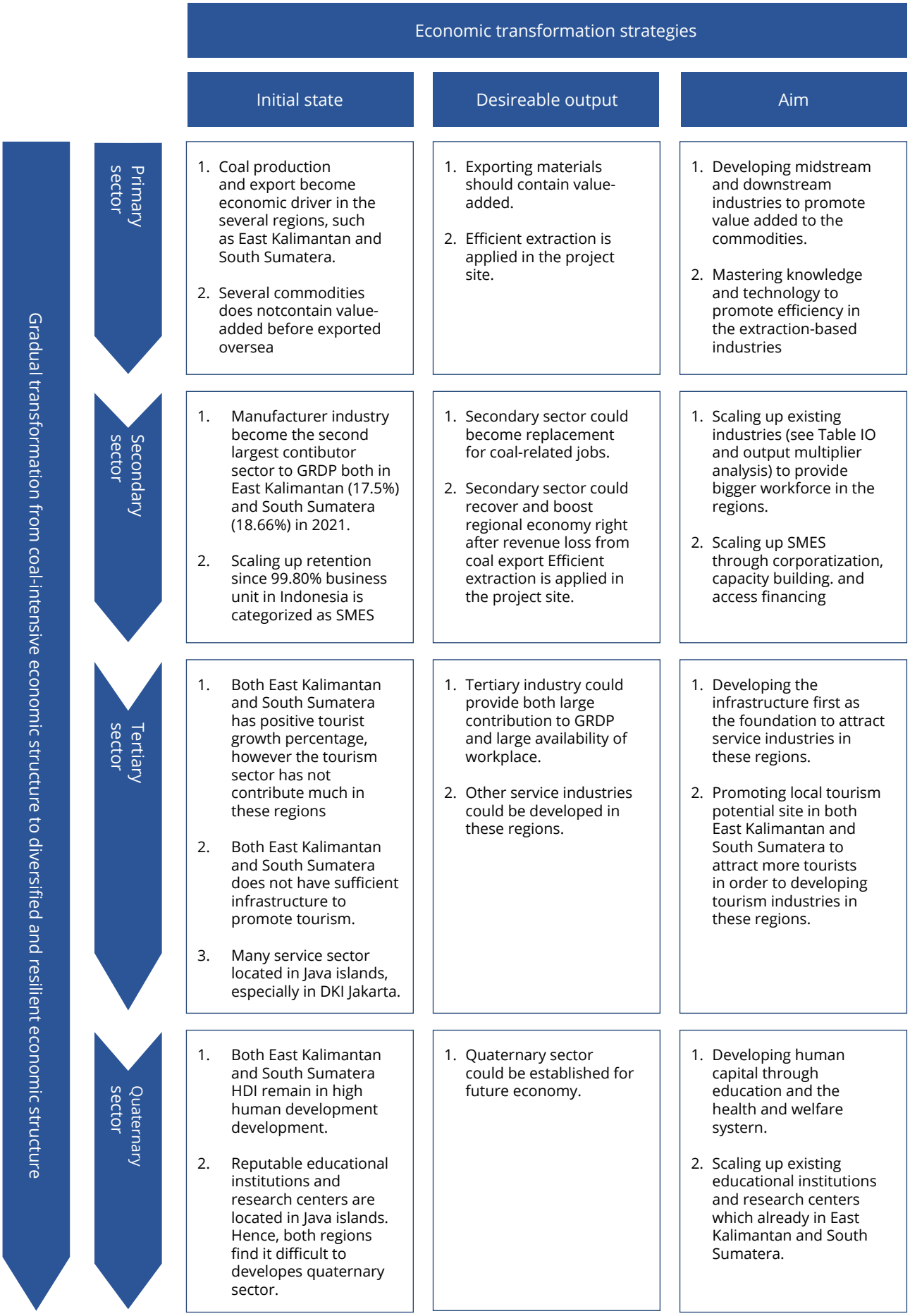


Figure 11. Economic transformation strategies for coal regions

5. Conclusion and recommendations

The international and national climate policies have negative implications for the coal industry, including employment. Under the current policies, the demand for Indonesian coal for the international and domestic market would slightly increase until 2030 before declining to around 500 million tons in 2050. However, based on the accelerated phase-out scenario compatible with the Paris Agreement, the demand would decline more rapidly by 20% by 2030 and 90% by 2050.

This plummeting demand for Indonesian coal would cause employment losses in the industry, especially when improved productivity and declined prices is considered. Under the current commitment scenario, employment loss could be significant as labor intensity declines due to reduced coal prices. The accelerated phase-out scenario would cause a more disruptive impact on coal employment.

The economy of some regions is highly dependent on coal mining, whose bleak future requires a structural transformation of these regions' economies. Coal export activity produces little value added to the economy, creates few employment opportunities, and has a high economic leakage. A sustainable economic transformation requires increased economic productivity, improved social equity, and environmental protection. Therefore, this study aimed to analyze the economic transformation opportunities and construct the pathway to be adopted by coal-dependent regions.

There are several examples of economic transformation in other coal regions in the past. The experiences highlight important aspects that determine successful economic transformations. These include government interventions, transformation approaches, community revitalization, and comparative advantages. The four aspects become enabling conditions for adapting and mitigating the economic impact of coal mine closures and transformation in those regions.

Coal-dependent regions could strategize the pathways to transition the workers and the economy. Impacted workers could be dispositioned within the company or find new opportunities in the new sectors. Additionally, training is crucial for the workers since they may fail to adapt to new jobs unrelated to current responsibilities. The coal regions' economic sector could pivot into existing key sectors with high output multiplier to prolong the economic benefits from these sectors' development.

The structural economic transformation in the coal regions could be implemented gradually to ensure long-term sustainability. Coal regions could develop the existing sectors and explore new ones to realize a diverse and resilient economy in the future. They could also strengthen their secondary sector by developing downstream industries and scaling up existing SMEs in the industry sector. Additionally, coal regions could prepare for the tertiary and quaternary sectors to anticipate the long-term economic shift.

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