CORE
INDONESIA
CENTER OF REFORM ON ECONOMICS

NARRATIVE REPORT

THE IMPACT OF EARLY COAL POWER PLANT RETIREMENT ON GDP, FISCAL POLICY, AND EMPLOYMENT IN INDONESIA

ABBREVIATIONS

AES	:	Average Electricity Subsidy
AHP	:	Analytical Hierarchy Proces
APBN	:	Anggaran Pendapatan dan Belanja Negara (State Budget)
BAU	:	Business as Usual
BESS	:	Battery Energy Storage System
BPS	:	Badan Pusat Statistik (Central Statistics Agency)
CAGR	:	Compound Annual Growth Rate
CFPP	:	Coal-Fired Power Plant
CGE	:	Computer General Equilibrium
CIT	:	Corporate Income Tax
CIPP	:	Comprehensive Investment and Policy Plan
CNY	:	Chinese Yuan (Currency)
CO	:	Carbon Monoxide
CO2	:	Carbon Dioxide
COGS	:	Cost of Goods Sold
CORE	:	Center of Reform on Economics Indonesia
CPI	:	Consumer Price Index
DMO	:	Domestic Market Obligation
ER	:	Exchange Rate
GHG	:	Greenhouse Gas
GoI	:	Government of Indonesia
GVA	:	Gross Value Added
GW	:	Gigawatt
GWh	:	Gigawatt-hour
HBA	:	Harga Batubara Acuan (Coal Price Reference)
IC	:	Installed Capacity
IDR	:	Indonesian Rupiah (Currency)
IESR	:	Institute for Essential Services Reform
ILO	:	International Labour Organization
IRENA	:	International Renewable Energy Agency
JETP	:	Just Energy Transition Partnership
KBLI	:	Klasifikasi Baku Lapangan Usaha Indonesia (Indonesian Standard Industrial Classification)
KEN	:	Kebijakan Energi Nasional (National Energy Policy)
KESDM	:	Kementerian Energi dan Sumber Daya Mineral (Ministry of Energy and Mineral Resources)
KRW	:	Korean Won (Currency)
LGES	:	LG Energy Solution
Minerba	:	Mineral dan Batubara (Mineral and Coal)
Mt	:	Million tonnes
MW	:	Megawatt
MWh	:	Megawatt-hour
NOx	:	Nitrogen Oxides
OECD	:	Organisation for Economic Co-operation and Development
PIT	:	Personal Income Tax
PLN	:	Perusahaan Listrik Negara (State Electricity Company)
PM	:	Particulate Matter

PNBP	:	Penerimaan Negara Bukan Pajak (Non-Tax State Revenue)
PTKP	:	Penghasilan Tidak Kena Pajak (Non-Taxable Income)
PLTS	:	Pembangkit Listrik Tenaga Surya (Solar Power Plant)
PLTU	:	Pembangkit Listrik Tenaga Uap (Steam Power Plant/Coal-Fired Power Plant)
R&D	:	Research and Development
RUKN	:	Rencana Umum Ketenagalistrikan Nasional (National Electricity General Plan)
SDA	:	Sumber Daya Alam (Natural Resources)
SNA	:	System of National Accounts
SO2	:	Sulfur Dioxide
SOx	:	Sulfur Oxides
TWh	:	Terawatt-hour
UU	:	Undang-Undang (Law)
USD	:	United States Dollar (Currency)
UN	:	United Nations
VAT	:	Value Added Tax
Wp	:	Watt-peak

EXECUTIVE SUMMARY

Indonesia's transition away from coal-fired power plants (CFPPs) represents both a significant **challenge and opportunity** for the national economy. This study examines three distinct scenarios: Business as Usual (BAU), Phase-Down (gradual transition), and Phase-Out (accelerated transition), analyzing their comprehensive impacts across GDP, fiscal revenues, and employment sectors through 2060. This analysis reveals that **early CFPP retirement, when coupled with strategic renewable energy development, can deliver net positive economic outcomes** in the medium to long term.

The GDP impact analysis demonstrates that although CFPP retirement would gradually reduce coal's economic contribution from 1.9% in BAU to 0.2% in Phase-Out by 2041-2050, this decline would be **more than offset by growth in renewable energy sectors**. The solar photovoltaic ecosystem, including module manufacturing and battery production, shows potential to contribute up to 659.8 trillion Rupiah in the Phase-Down scenario and 709.2 trillion Rupiah in the Phase-Out scenario by 2051-2060, significantly exceeding the 561.5 trillion Rupiah lost from the coal sector. Macroeconomic modeling confirms that while the initial transition period (2024-2030) experiences slightly lower GDP growth compared to BAU, this pattern reverses in subsequent decades, with the Phase-Out scenario achieving the **highest long-term growth rate of 1.39%** by 2051-2060.

From a fiscal perspective, the transition presents a structural shift in government revenue streams. While traditional revenue from coal-related activities would decline substantially, the solar PV sector and its manufacturing supply chain could generate **tax revenue potentially exceeding 491 trillion Rupiah annually** by 2051-2060 in the Phase-Out scenario. Additionally, transitioning from direct electricity subsidies to installation subsidies for solar infrastructure presents a more fiscally sustainable approach, with electricity subsidies decreasing consistently from 46 trillion Rupiah (2024-2030) to zero by 2051-2060 in the Phase-Out scenario. The employment impact analysis yields particularly promising results, showing that job losses in coal mining and power generation would be **significantly outweighed by new employment opportunities** in renewable energy sectors, with the solar PV ecosystem potentially creating over 1.25 million jobs by 2060 in the Phase-Out scenario—a sixteen-fold increase compared to the 77,000 jobs supported by the coal sector in the BAU scenario.

For successful implementation, expert analysis through the Analytical Hierarchy Process identified a **clear preference for regulatory intervention** through the Rein-in strategy (0.551) over Buy-out (0.253) and Crowd-out (0.170) approaches. Carbon taxation (0.470) emerged as the most important policy tool, while subsidy reallocation to renewable energy (0.459) was prioritized under the Buy-out approach. Implementing these strategies requires careful synchronization between coal phase-out and renewable energy development, redirecting existing subsidies, supporting local manufacturing through industrial scaling policies, implementing progressive carbon taxation, limiting new coal exploration, and ensuring comprehensive worker compensation and retraining programs. With appropriate planning and policy implementation, Indonesia can achieve its climate commitments while securing economic growth, fiscal sustainability, and expanded employment opportunities.

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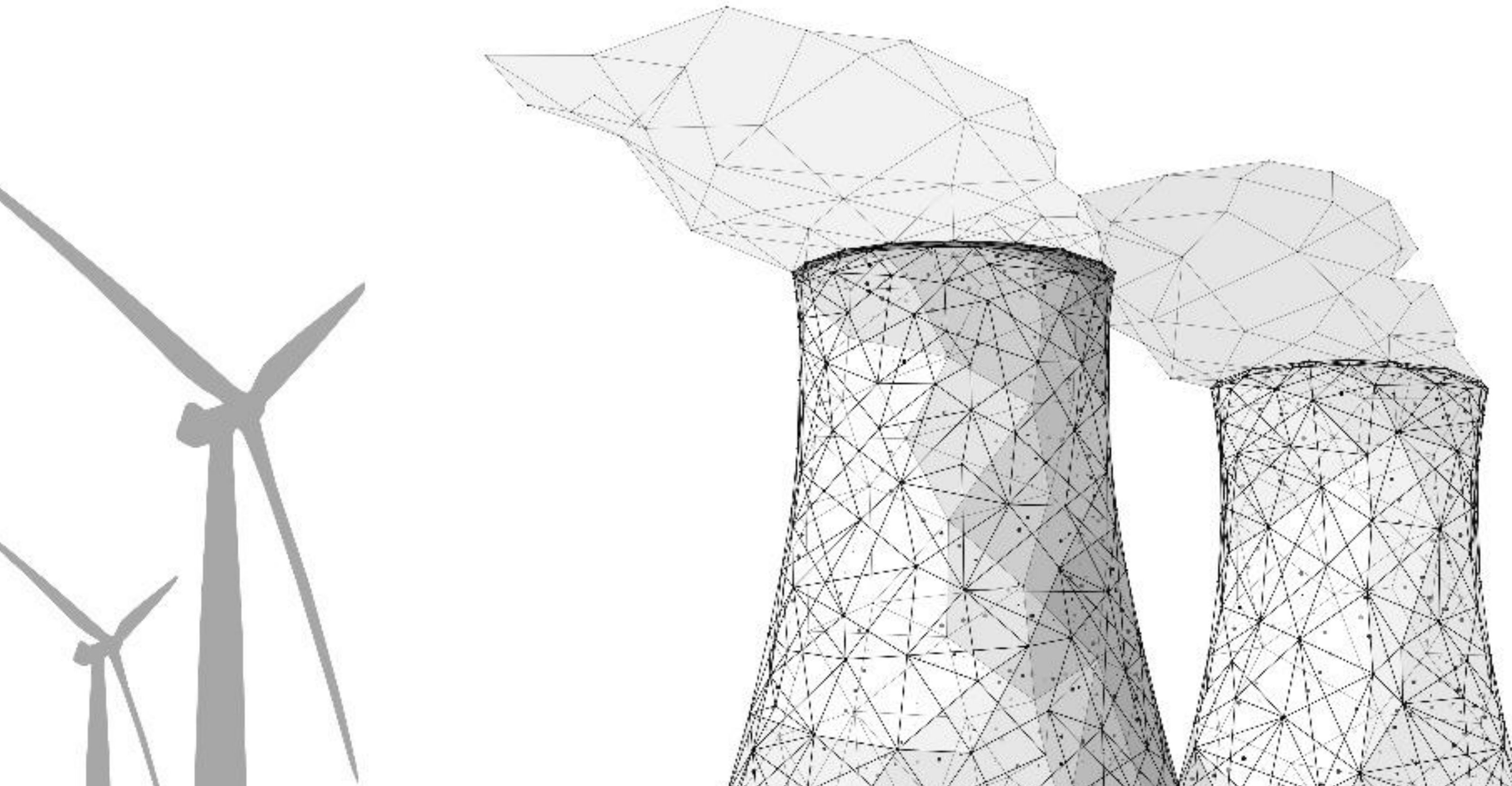
INTRODUCTION



1.1 Background

The Government of Indonesia (GoI) has enacted Presidential Regulation No. 112 of 2022 to accelerate renewable energy development and enable early retirement of coal-fired power plants (CFPPs). Phasing out coal use has become a priority in Indonesia's national energy policy, given its significant contribution to carbon emissions. Complementing this, GoI is committed to increasing clean energy use as outlined in Government Regulation No. 79 of 2014 and renewed in the National Electricity General Plan (RUKN) 2024-2060. The government has set a target to achieve a 23% share of renewable energy in the energy mix by 2025.

Regarding global commitments, Indonesia is a signatory to the Paris Agreement, aiming to achieve net-zero emissions by 2060 or sooner. GoI has committed to reduce greenhouse gas emissions by 29% independently and 41% with international assistance by 2030. Additionally, GoI also has signed strategic initiatives, such as the Just Energy Transition Partnership (JETP) launched in 2022 with a funding package of USD 20 billion, which aims to finance a gradual coal phase-out while accelerating the development of renewable energy sources such as solar and geothermal power (JETP, 2023).

However, according to the Ministry of Energy and Mineral Resources (KESDM, 2024), the energy mix target remains unmet, with coal still dominating 64.3% of installed power capacity in 2023. The lack of incentives is a key factor in the insufficient achievement of the energy mix target and the delayed transition to clean energy (Do and Burke, 2023; Du et al., 2024).

The energy transition and CFPP phase-out require substantial financial support and it could significantly affect the subsidy structure, with current annual energy subsidies reaching around Rp 140 trillion, mostly for fossil fuels. The implementation of the energy transition, especially the CFPP phase-out will also impact the realization of non-tax state revenue (PNBP), especially from the mineral and coal mining (Minerba) sector, which reached Rp 173 trillion or 58% of the total PNBP in 2023.

The phase-out of coal-fired power plants presents both challenges and opportunities across multiple economic dimensions. According to ILO data, in 2019 approximately 1.4 million out of Indonesia's 128.8 million workforce were employed in the mining and quarrying sector. While this represents only about 1.1% of total national employment, the impact of coal mine closures would be particularly significant at the regional level, affecting not only direct mining industry workers but also related sectors such as transportation and power plant operations.

However, the transition to renewable energy sources offers promising economic potential. The adoption of green energy technologies can drive economic growth through new industry development, create high-quality jobs in the renewable sector, and potentially increase government fiscal space in the long term. The consistently decreasing costs of renewable technologies, combined with reduced dependency on fossil fuel subsidies, could provide substantial economic benefits as the energy transition progresses.

Based on this background, CORE Indonesia aims to identify the impact of the CFPP phase-out on fiscal conditions and socio-economic conditions as well as employment and gross value-added. This analysis will help inform evidence-based policies to support an effective and equitable energy transition while maintaining economic stability and growth.

1.2 Objectives of Study

This study aims to analyze the economic implications of transitioning away from coal-fired power plants in Indonesia while promoting renewable energy development. Specifically, this research aims to:

1. To analyze and quantify the economic impacts of coal-fired power plant phase-out on Indonesia's national GDP, fiscal revenues from coal-related activities, and employment across the coal mining and power generation sectors.
2. To assess the economic opportunities from solar power development through analysis of GDP contributions from photovoltaic manufacturing and electricity generation sectors, job creation potential in the renewable energy industry, and new sources of fiscal revenue from clean energy development.
3. To develop comprehensive policy recommendations and transition strategies at the national level to mitigate negative socioeconomic impacts while accelerating renewable energy adoption through targeted incentives, workforce development programs, and supportive regulatory frameworks.

1.3 Literature Review

The energy transition in Indonesia holds significant potential to reshape its energy landscape, driven by substantial renewable energy resources and ambitious governmental targets. Indonesia possesses a vast potential for renewable energy, with an estimated 75 gigawatts (GW) of solar power and an equally impressive biomass potential across various regions, as highlighted by Langer et al. (2021) and Pambudi et al. (2023). The government has set a clear roadmap, outlined in Presidential Decree No. 112/2022, to increase the share of renewable energy to 23% by 2025, with a long-term goal of achieving a complete transition by 2040-2060. This shift is expected to stimulate economic growth by fostering technological advancements and creating substantial job opportunities, particularly in the renewable energy sector, as noted by Timilsina (2021) and Dell'Anna (2021).

The global investment climate and domestic policy frameworks further amplify the potential impacts of this transition. The growing global focus on green investments, with Indonesia attracting attention for its green financing initiatives (IEA, 2024), is poised to enhance the country's international standing. Social and geopolitical benefits are also anticipated, including improved air quality and biodiversity conservation, as emphasized by Ceribozan (2022) and Gökgöz & Güvercin (2018). Additionally, the transition could strengthen national energy security by reducing reliance on imported energy, thereby bolstering economic resilience. These factors collectively suggest that Indonesia's energy transition could yield multifaceted benefits, provided the necessary infrastructure and policy support are effectively implemented.

Coal, one of the largest contributors to global emissions, has been a primary energy source for industrial development and power generation across nations for centuries. Currently, coal still accounts for approximately 38% of global electricity generation, with China and the United States being the largest consumers, representing 58% of the world's coal-fired power generation (Hendryx et al., 2020). Although coal has played a vital role in economic development, its utilization poses significant adverse impacts on human health, the environment, and socioeconomic aspects of communities.

The use of coal as an energy source has profound negative impacts across multiple dimensions, affecting the climate, human health, ecosystems, and social-economic structures. In terms of climate change, coal combustion is a major contributor to global warming. According to Edwards (2019), coal contributes approximately 41 teragrams per year ($Tg\ yr^{-1}$) of methane emissions, accounting for 10–12% of total global anthropogenic methane emissions. Additionally, coal combustion releases significant amounts of carbon dioxide (CO_2) and other greenhouse gases, with emissions in the United States alone constituting 30% of the country's total in 2014, as reported by the U.S. Environmental Protection Agency (EPA). Globally, coal-related emissions were responsible for 46% of greenhouse gas emissions in 2018, a figure highlighted by Oberschelp et al. (2019). This substantial contribution exacerbates global warming, leading to rising temperatures, extreme weather events, and long-term climate disruptions.

Beyond its role in climate change, coal combustion has severe consequences for human health and ecosystems. The process releases a range of harmful pollutants, including carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter (PM), and heavy metals such as mercury. These pollutants are linked to numerous health issues, including respiratory and cardiovascular diseases, developmental disorders in children, IQ reduction, and premature death, as noted by Munawer (2018) and Hendryx et al. (2020). Ecosystems are similarly affected, with pollutants causing acid rain, which damages forests, soils, and aquatic environments. Research by Widiawaty et al. (2021) and Singh et al. (2022) underscores how coal-related activities increase chlorofluorocarbon levels in water, disrupt microbial ecosystems, and elevate sea surface temperatures, leading to the destruction of aquatic life and broader ecological imbalances.

The environmental devastation caused by coal extends to agricultural systems and water resources, further compounding its ecological footprint. Coal-related pollutants contribute to soil degradation, reduced crop yields, and the contamination of water bodies, as highlighted by Munawer (2018) and Hendryx et al. (2020). Acid rain and heavy metal deposition from coal combustion damage farmland, while coal mining and waste disposal introduce toxins into groundwater and surface water, threatening both human and ecological health. Additionally, coal combustion releases significant amounts of greenhouse gases like methane and nitrous oxide into the atmosphere, which not only contribute to climate change but also harm plants, disrupt agricultural productivity, and degrade air and water quality, as noted by Kravchenko & Ruhl (2021) and Munawer (2018).

Finally, the social-economic consequences of coal use are equally concerning, with coal-related pollution and environmental degradation disproportionately affecting vulnerable communities. Hendryx et al. (2020) and Mardiyono & Han (2023) emphasize that coal combustion contributes to poverty by damaging ecosystems that communities rely on for livelihoods, such as agriculture and fishing. The health impacts of coal pollution also impose significant economic burdens, including increased healthcare costs and reduced workforce productivity. Moreover, the reliance on coal perpetuates a cycle of environmental injustice, as marginalized populations often bear the brunt of pollution and resource depletion, further exacerbating social inequalities. The cumulative effects of coal use highlight its role as a major driver of environmental, health, and social challenges, necessitating a shift toward cleaner, more sustainable energy alternatives.

Due to these detrimental effects, there is growing momentum globally for energy transition initiatives to move away from coal dependency. One key approach is coal phase-out, which refers to the complete elimination of unabated coal power generation within a time-bound planning schedule, rather than an immediate halt of all coal usage across sectors (Do & Burke, 2024). This transition has become a core goal as countries work to achieve carbon neutrality targets, given that coal accounts for approximately 40% of global carbon dioxide emissions and plays a major role in accelerating climate change (Munawer, 2018). The recognition and implementation of coal phase-out policies by more than 130 countries signals that moving away from coal power will increasingly influence and dominate energy transformation strategies worldwide (Shah et al., 2024).

The impacts of coal phase-out are multifaceted. From an environmental perspective, reducing coal usage significantly decreases air pollutant emissions including SOx, NOx, and particulate matter, which helps minimize premature mortality and improve life expectancy (Munawer, 2018). Economically, coal phase-out can help avoid the risk of stranded assets as global financing shifts away from coal infrastructure (Shah et al., 2024). However, there are also potential negative impacts including rising electricity prices, power supply instability, and job losses in coal-dependent regions (Do & Burke, 2024).

Challenges of Coal Phase Out

However, the implementation of coal phase-out policies in Indonesia faces multiple interconnected challenges across different dimensions that need to be mitigated properly by multistakeholders:

- **Economic and Financial Challenges:** The most fundamental barrier is economic, with dual concerns around costs and market dynamics. Indonesia faces estimated costs of US$114 billion to decommission existing coal plants and transition to clean energy, with approximately US$1.9 billion needed per gigawatt. The challenge is amplified by current artificially low electricity costs maintained through coal power subsidies, creating concerns about potential price increases that could impact both consumers and industries (Do & Burke, 2024; Shah et al., 2024).
- **Industry Power and Coal Dependence:** Indonesia's deep economic dependence on coal creates powerful resistance to phase-out. As the world's largest coal exporter with US$46.8 billion in revenues (2022) and holder of the world's 7th largest coal reserves, the coal industry exercises substantial influence over policy. The domestic market obligation requiring 25% of production for local power generation at subsidized prices (US$70/ton or below) further entrenches coal's dominance (Do & Burke, 2024; Shah et al., 2024).
- **Political and Institutional Barriers:** Strong political resistance emerges from multiple institutional stakeholders. Local governments and coal-related enterprises strongly oppose phase-out efforts, particularly given the industry's significant political influence in energy policymaking. The young age of Indonesia's coal fleet (averaging 10 years) makes early retirement politically contentious, complicated by electoral considerations in coal-dependent regions (Do & Burke, 2024; Kou et al., 2022).
- **Technical and Infrastructure Limitations:** Indonesia's archipelagic geography of 16,000 islands presents unique technical hurdles in grid infrastructure and power transmission, especially to Java where demand concentrates. PLN's limited experience with variable renewable energy and the prohibitive costs of carbon capture technology add significant technical complexity to the transition (Do & Burke, 2024).
- **Social Challenges:** Communities face significant transition impacts, particularly in coal-dependent regions where many rely on the industry for livelihoods. Social resistance grows when communities doubt the transition's ability to maintain economic stability. Renewable energy projects face additional opposition when communities feel excluded from decision-making or receive inadequate compensation (Do & Burke, 2024; Kou et al., 2022).
- **Regulatory Framework Gaps:** Significant regulatory gaps exist in managing coal assets, job transitions, and closure compensation. Current regulations favor coal power, especially for captive coal projects, while renewable energy faces restrictive

policies like the 60% local content requirement for solar systems (Do & Burke, 2024; Shah et al., 2024).

- **Energy Security Concerns:** Maintaining reliable power supply during transition poses significant challenges. Vietnam's experience with 4.3 GW power shortages in 2023 demonstrates the importance of careful planning for grid stability, particularly given Indonesia's growing energy demands and coal's current baseload role (Do & Burke, 2024).
- **International Commitment Implementation:** While Indonesia has secured US$20 billion through JETP, implementing these commitments faces complex challenges in determining priorities, structuring financial support, and creating effective risk mitigation measures. Most Indonesian experts (71%) expect complete coal phase-out to extend beyond 2050 due to these multiple challenges (Do & Burke, 2024; Shah et al., 2024).

Therefore, successfully phasing out coal demands a whole-systems approach that integrates multiple justice dimensions—procedural, distributive, recognition, and restorative (Abram et al., 2022). This requires balancing stakeholder interests while securing energy, economic stability, and social welfare. Neglecting these aspects risks strong resistance and implementation setbacks (Kou et al., 2022). The following strategies outline how to achieve this transition effectively.

- **Justice and Social Framework:** A successful coal phase-out demands a comprehensive approach rooted in justice—procedural, distributive, recognition, and restorative—while balancing stakeholder interests to ensure energy security, economic stability, and social welfare (Abram et al., 2022). Public support, stronger in wealthier nations, hinges on affordable, reliable energy alternatives, making social acceptance and equitable transitions critical to overcoming resistance (Kou et al., 2022).

- **Policy and Governance:** Effective phase-out relies on policy tools like carbon pricing, cutting fossil fuel subsidies, and supporting a "just transition" through worker retraining and community aid (Pressburger et al., 2022). Germany's success—clear targets, compensation, and renewable investment—shows the need for long-term planning (Do & Burke, 2024). Governance aligns central and local governments, businesses, and communities via robust regulations, enforcement, and compensation schemes (Kou et al., 2022).

- **Global and Contextual Support:** Developed nations often set firm phase-out deadlines, while developing nations face challenges balancing emissions goals with rising energy needs and affordability (Shah et al., 2024; Pressburger et al., 2022). International cooperation, like Just Energy Transition Partnerships (JETPs), provides financial and technical aid to accelerate transitions, though success depends on clear implementation and financing terms tailored to each context (Do & Burke, 2024).

- **Technological Solutions:** Falling renewable energy costs challenge coal's viability, but grid integration and storage remain hurdles (Shah et al., 2024). Carbon capture and storage (CCS) could reduce emissions, yet high costs limit widespread adoption (Munawer, 2018). Technological advancements are key to enabling reliable, scalable alternatives.

1.4 Scope and Limitation

Several important limitations bound this research. The geographic coverage is restricted to national-level analysis and does not examine regional or local economic impacts. This study analyzes the national-level economic implications of transitioning from coal-fired power plants to solar power or solar photovoltaic (solar PV) in Indonesia. The scope encompasses two main areas of analysis.

1. The study examines the economic impacts of coal phase-out in three distinct scenarios (see Table 2) by assessing changes in national GDP contribution from coal mining and electricity generation sectors, impacts on government fiscal revenues from coal-related activities and government spending for electricity subsidies, and employment effects in coal mining and power generation sectors at the aggregate national level.
2. Second, the research evaluates economic opportunities from solar power development through analysis of GDP contributions from electricity generation, solar module manufacturing and battery manufacturing, job creation potential in these sectors, and new fiscal revenue streams from solar PV ecosystem manufacturing and clean electricity generation.

Table 1 Early Coal Power Plant Retirement Scenarios

Scenario	I Business as Usual (BaU)	II Coal Phasing-Down	III Coal Phasing-Out
Description	**No transition**. All CFPPs that are currently being planned and constructed will be built and operate as intended.	**Moderate scenario**. Existing CFPPs may operate until their book value reaches zero. CFPPs still under construction are only allowed to operate until 2030.	**Ambitious scenario**. Existing CFPPs may only operate for 20 years. CFPPs still under construction are canceled.
Data and References	Draft RUKN (2023), Clark dan Zhang (2022)	RUKN (2024), Clark and Zhang (2022);	RUKN (2024) JETP CIPP (2023)

1.5 Data and Methodology

Table 2 Matrix of Objectives and Methodology

Objective	Aspect	Data	Method Analysis Data
1. To analyze the economic impacts of CFPP phase-out; **2. To assess the economic opportunities from solar power development;**	GDP	Secondary	1. Gross Value-Added Analysis; 2. Computer General Equlibrium (CGE).
	Fiscal	Secondary	1. Fiscal Impact Analysis; 2. Computer General Equlibrium (CGE).
	Employment	Secondary	1. Employment Impact Analysis; 2. Computer General Equlibrium (CGE).
3. To develop comprehensive policy recommendations and transition strategies.	Mitigation Policy	Primary, secondary	1. Studi Literature; 2. Analytical Hierarchy Process (AHP)

1.5.1 Data and Methods for Estimating the GDP Impact

To analyze the economic impact of the early retirement policy for coal-fired power plants (CFPPs), this study employs a gross value added (GVA) analysis approach based on the UN System of National Accounts (SNA) 2008 framework, focusing on two key sectors within Indonesia's Standard Industrial Classification (KBLI): the electricity sector and the coal mining sector. This methodology, which aligns with the value-added calculation methods used by Indonesia's Central Statistics Agency (BPS), enables a detailed examination of policy implications across these interconnected industries within their respective KBLI classifications.

In addition, the GVA calculation is also applied to the solar PV sector and its industrial ecosystem, including the solar panel module industry and battery industry, as these represent the assumed replacements for early-retired CFPPs. This analysis encompasses the entire value chain of renewable energy alternatives, considering both the direct power generation facilities and the supporting manufacturing industries required for the energy transition. The formula used in this study is as detailed in Appendix 1.

The GVA calculation in this study may not comprehensively cover every aspect of their supply chains due to research limitations. This analysis also employs various assumptions including units of measurement, national standards, and international standards, as detailed in Appendix 4.

1.5.2 Data and Methods for Estimating the Fiscal Impact

Using a structured fiscal impact assessment approach, this study evaluates the fiscal impact of the early retirement policy for coal-fired power plants (CFPPs). The analysis follows the methodology proposed by Clark and Zhang, which quantifies potential state revenue losses, encompassing both tax and non-tax revenues, and the potentially avoided electricity subsidies resulting from the early retirement of CFPPs.

The assessment focuses on two primary sectors: the coal mining sector and the electricity sector. The methodology applied in this study aligns with the tax and subsidy calculation framework adopted by the Ministry of Finance. Specifically, the estimation of potential lost state revenue considers various fiscal components, including value-added tax (VAT), corporate income tax (CIT) in the coal mining sector, personal income tax, and coal royalty revenues. In parallel, the estimation of potentially avoided subsidies primarily concerns electricity subsidies associated with CFPP operations.

Furthermore, the study extends its fiscal impact analysis to the solar photovoltaic (PV) sector and its supporting industrial ecosystem, encompassing solar panel module manufacturing and battery production industries. These sectors are considered as potential replacements for the early-retired CFPPs, thereby introducing new state revenue streams and adjustments in subsidy allocations linked to the expansion of renewable energy alternatives. The specific formulas employed in this study are outlined as detailed in Appendix 2.

It is important to acknowledge that the fiscal impact assessment presented in this study may not fully capture all dimensions of state revenue variations and other subsidy adjustments, given certain research limitations. The analysis also incorporates several assumptions, including measurement units, tax rate estimates, and other key parameters, as detailed in Appendix 5.

1.5.3 Data and Methods for Estimating the Employment Impact

In the context of analyzing early retirement policies for coal-fired power plants (CFPPs), employment aspects within both electricity and coal mining sectors are evaluated in this study. The methodological approach adopts Clark and Zhang's (2022) model with relevant adjustments for the Indonesian context.

The labor analysis is conducted through a two-stage calculation process with more detailed in Appendix 3. First, the number of workers in coal-fired power generation is calculated by multiplying CFPP installed capacity (MW) by labor intensity (workers per MW). This approach estimates the total workforce involved in power plant operations based on installed capacity. For specific CFPPs, an alternative method considering the worker-to-capacity ratio may be employed as a multiplier. Second, coal mining sector employment is calculated by multiplying total coal production (billion tons) by mining sector labor intensity (workers per billion tons). This method quantifies the impact of production changes on mining employment. For specific mines, the worker-to-production ratio approach can be utilized as a multiplier.

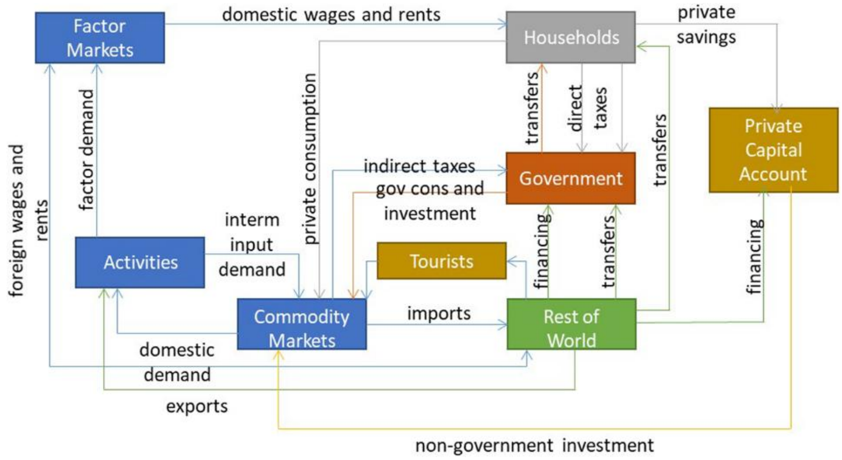
To complement this analysis, employment aspects in the solar panel sector are also evaluated as a renewable energy alternative, providing essential insights into potential job creation from energy transition. Labor calculations for solar power plants (SPPs) employ a similar methodology, multiplying installed capacity by labor intensity specific to this sector, as detailed in Appendix 6. It should be noted that SPPs generally exhibit more labor-intensive characteristics than capital-intensive CFPPs, particularly during construction and installation phases.

The employment analysis extends to the industrial supply chain, encompassing solar panel module manufacturing and battery production as energy storage components. For manufacturing, calculations multiply production capacity by manufacturing labor intensity, while battery industry employment is determined through the multiplication of battery production capacity (MWh) by sector-specific labor intensity.

1.5.4 Data and Methods for Evaluating the Overall Economic Impact of Energy Transition

This research employs a Computable General Equilibrium (CGE) approach to analyze the economic impacts of coal power plant phase-out and transition to solar power generation as its substitute. The CGE model was selected for its capability to comprehensively analyze structural economic changes while considering intersectoral linkages in the economy. The CGE model adopts a circular flow approach that illustrates income and expenditure flows within the economy. This model encompasses interactions between production factors (labor and capital), sectoral production activities, commodity markets, and various institutions such as households, government, and the foreign sector. The model is constructed with several key assumptions: market equilibrium conditions, economic agents' optimization behavior, CES (Constant Elasticity of Substitution) production function, inter-sectoral labor mobility, and short-term rigid capital. The model closure includes savings-driven investment, flexible exchange rate, fixed government expenditure, and endogenous tax revenue. This enables the model to achieve a new equilibrium following policy shocks.

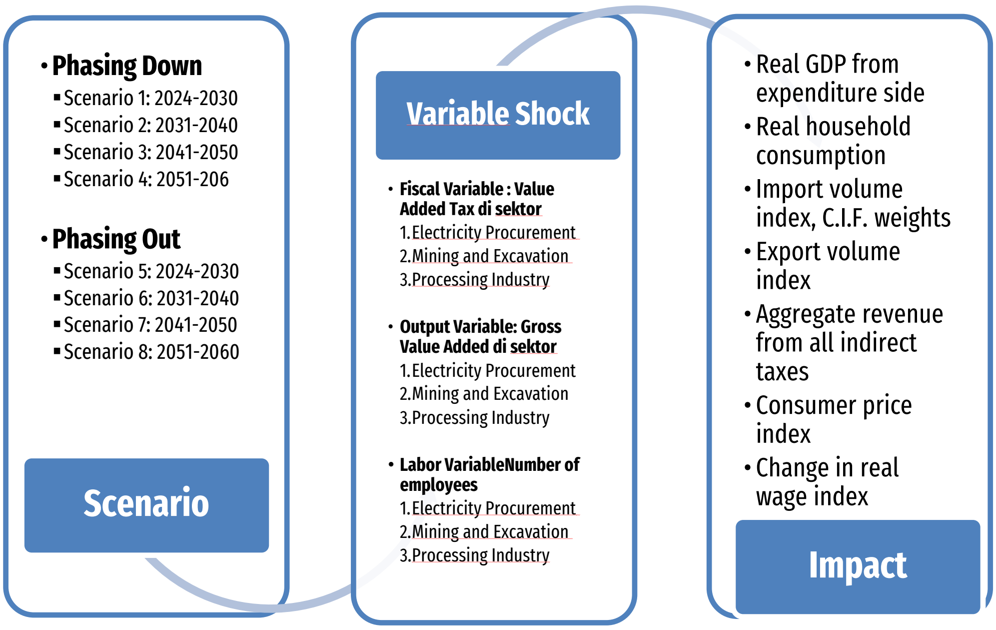
Figure 1 Circular Flow of Income and Expenditure within the Economy System



Source: Burfisher (2020)

The primary data used in the analysis includes the latest Indonesian Input-Output Tables, sectoral employment statistics from BPS, sectoral GDP data, and sectoral VAT revenue data. Supporting data includes information on coal power plant capacity, solar energy potential, power plant investment costs, and sectoral carbon emissions data. Simulations are conducted under two main scenarios: phase-down and phase-out. The shock variables include fiscal variables: value added tax, output variables: gross value added, and labor variables. The simulated sectors are mining and quarrying, electricity and gas supply, and manufacturing industry.

Figure 2 Scenarios and CGE Stimulus Variables



Source: Analysis of author from various sources

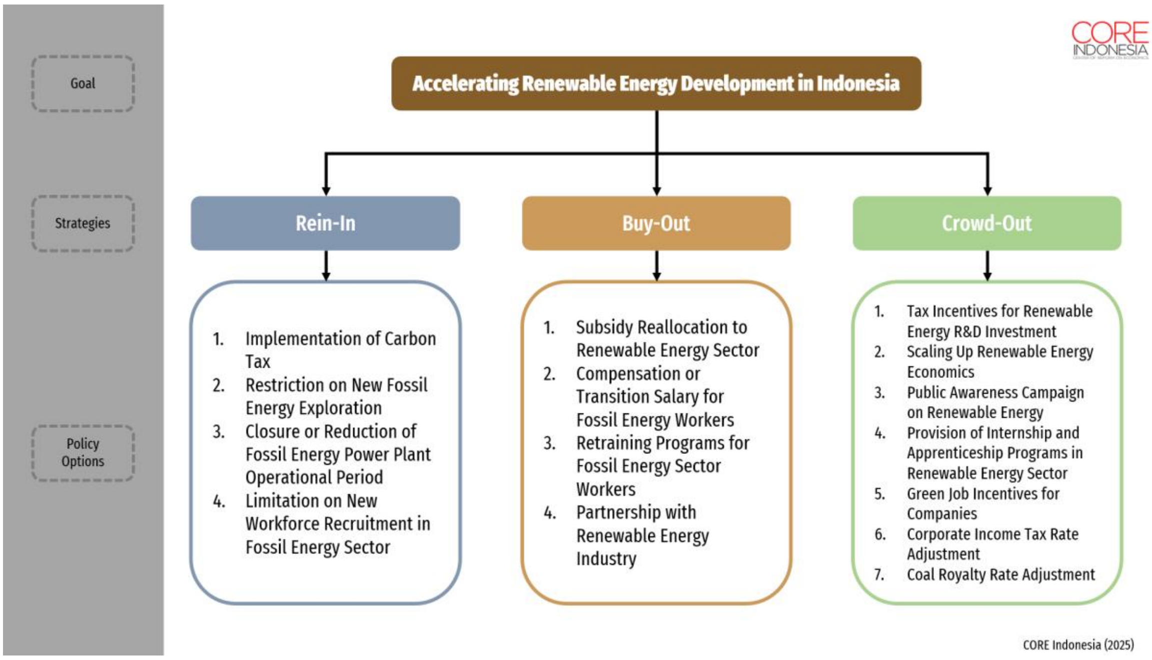
The study encompasses 8 scenarios including Phasing Down (2024-2060), representing gradual transition from coal power plants to renewable energy divided into four time periods with distinct characteristics. Beginning with the initiation phase in 2024-2030 focusing on market adaptation and basic infrastructure development. Continuing to the acceleration phase (2031-2040) with increased renewable energy capacity and strengthened industrial ecosystem. The 2041-2050 period marks substantial transformation where renewable energy begins to dominate, ending with transition consolidation (2050-2060) characterized by system optimization and market stabilization. Subsequently, the Phasing Out Scenario (2024-2060) implements total coal power plant termination in four stages. Starting with aggressive termination of old coal power plants (2024-2030) accompanied by massive new infrastructure investment. Followed by acceleration phase (2031-2040) with comprehensive energy industry restructuring. The 2041-2050 period focuses on technology optimization and market stabilization, concluding with total elimination of coal power plants in 2050-2060 towards 100% renewable energy system.

Impact analysis covers three main dimensions: economic, fiscal, and social. Economic impacts are measured through GDP changes. Economic impacts are measured by changes in real GDP, household consumption, CPI, and export-import volumes. Meanwhile, fiscal impacts are measured by changes in indirect tax revenue. Labor market impacts are measured by changes in the real wage index.

1.5.5 Data and Methods for Determining Mitigation Policy to Support the Energy Transition

This study employs the Analytical Hierarchy Process (AHP) method developed by Saaty (1990) to systematically evaluate and prioritize mitigation policies supporting energy transition initiatives in Indonesia. The research collected primary data through structured questionnaires on CORE Indonesia's Focus Group Discussion on 16th of January 2025 administered to a panel of 10 experts representing diverse stakeholders in the energy sector, including government official, industry association representative, think-tank researcher, and NGO practitioner with extensive experience in energy transition. These experts were tasked with conducting pairwise comparisons and assigning relative importance scores across multiple criteria and alternatives within the established decision hierarchy model (see Figure 3), enabling a comprehensive assessment of strategic mitigation policies through the calculation of priority weights and consistency ratios.

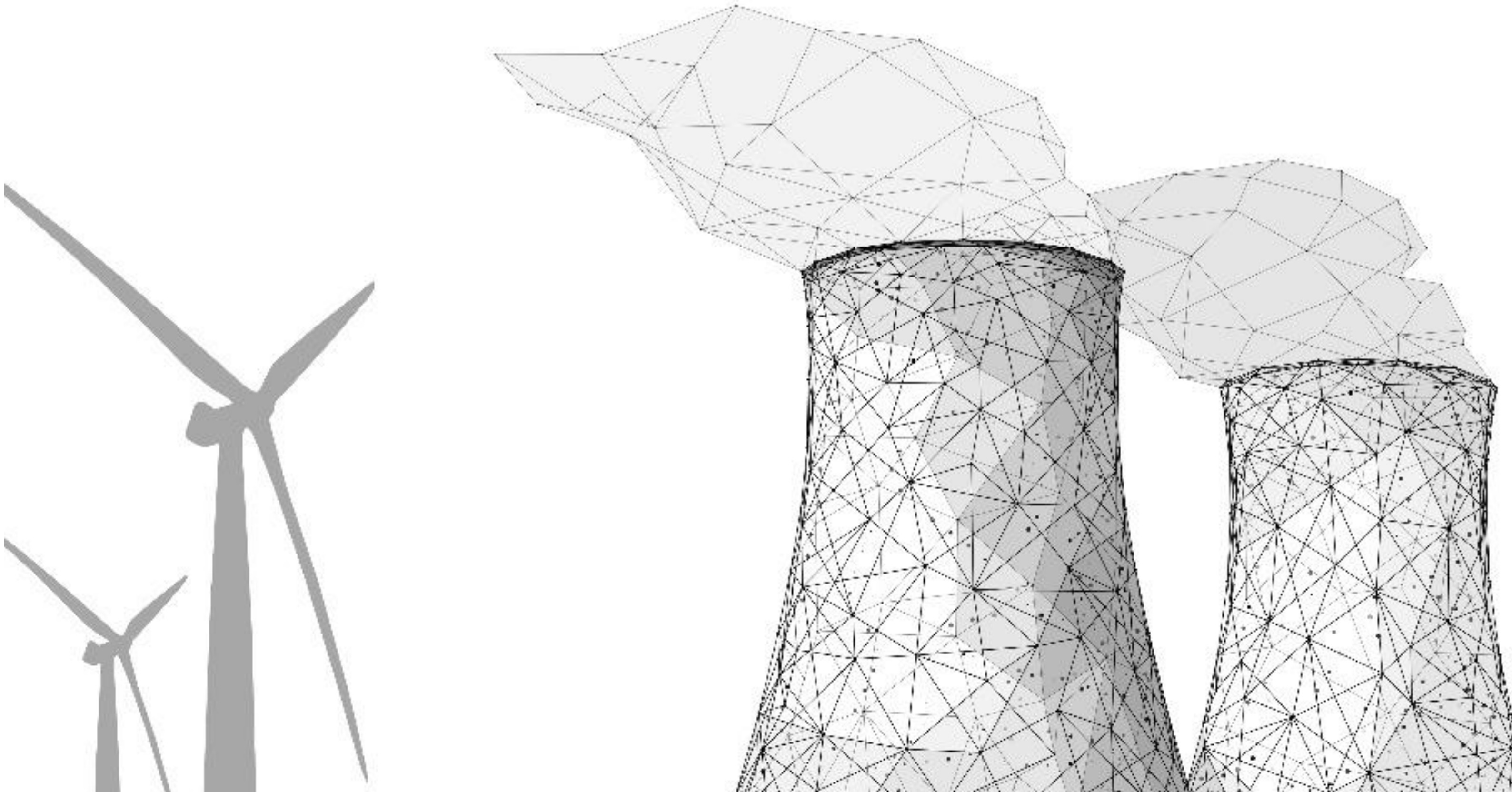
Figure 3 CORE Indonesia's Decision Hierarchy Model of Mitigation Strategy to Support the Energy Transition in Indonesia



Source: Analysis of author from various sources

CHAPTER II

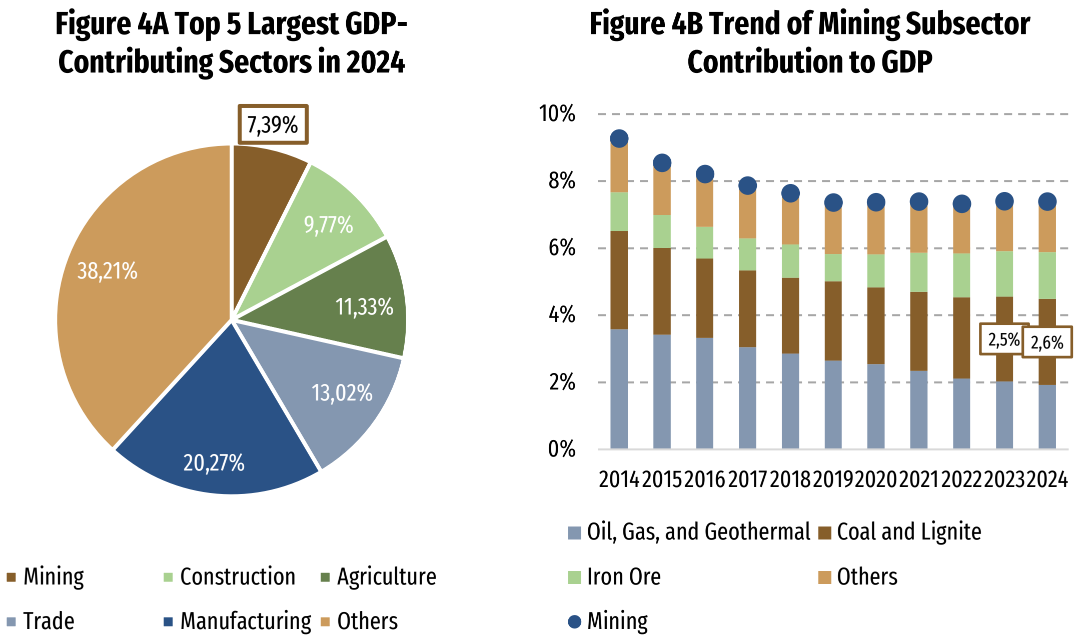
GDP IMPACTS OF EARLY COAL POWER PLANT RETIREMENT IN INDONESIA



2.1 Current Condition of GDP in the Coal-Related Sector

Coal has played a substantial role in shaping Indonesia's macroeconomic indicators, with its influence extending across multiple sectors of the economy. Within the sectoral composition, mining has established itself as one of the five largest contributors to the national GDP, accounting for a significant 7.4% in 2024. More specifically, coal and lignite mining has demonstrated remarkable stability, maintaining a steady contribution of approximately 2.5% to Indonesia's GDP over the past decade (see Figure 4) (BPS, 2025).

Figure 4 Coal Mining Sector Contribution to GDP



Source: Adapted from BPS (2025)

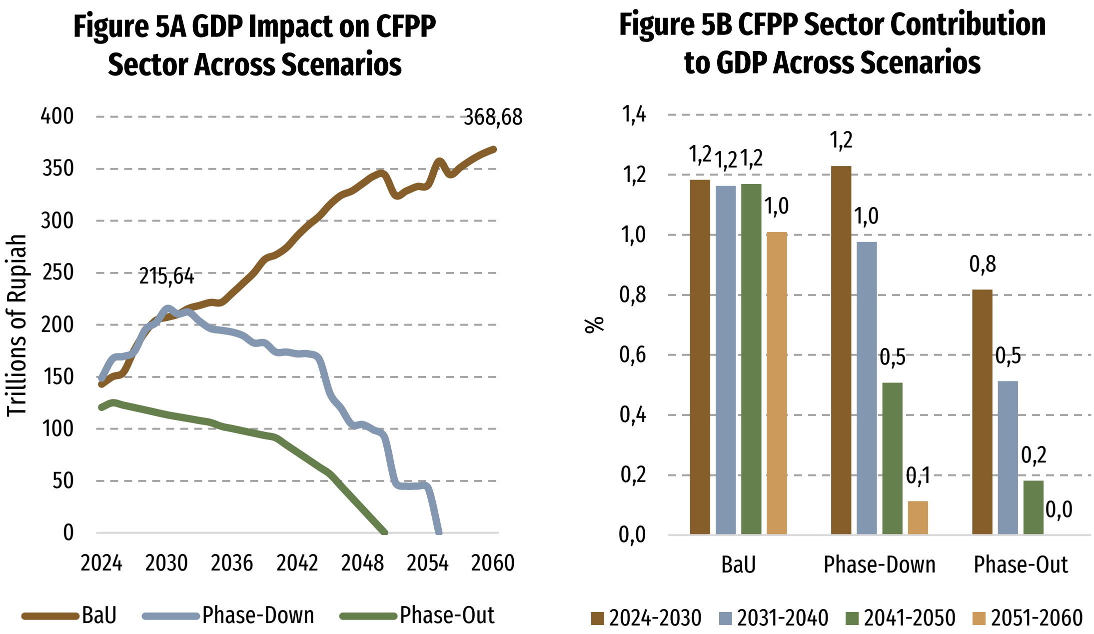
Coal's economic impact extends beyond the mining sector through its strong intersectoral linkages. In the manufacturing sector, the coal and oil refining subsector has maintained a consistent average contribution of 2.1% to GDP over the past decade. Additionally, in the utilities sector, the electricity subsector, which relies heavily on coal for power generation, has contributed an average of 0.9% to GDP during the same period. When combined, these coal-related activities across different sectors - direct mining, industrial processing, and power generation - account for approximately 5.5% of Indonesia's GDP (BPS, 2025). This figure highlights the commodity's significant role in the nation's economic structure, though critics argue these figures do not account for the substantial environmental and social costs associated with coal-related activities in Indonesia's national accounts.

2.2 Projection of Early Coal Power Plant Retirement Impact on GDP

2.2.1 GDP Impact on Coal-fired Power Plant Sector

Based on the graphs depicting the Gross Value Added (GVA) and GDP contribution projections for Coal-Fired Power Plants (CFPP) in Indonesia, three distinct scenarios emerge. In the Business as Usual (BaU) scenario, CFPP's GVA shows a steady upward trend, reaching approximately Rp 368.68 trillion by 2060. This continuous growth aligns with the increased installed capacity of coal-fired power plants. Looking at GDP contributions, the BaU scenario maintains a consistent level of around 1.2% across the first two decades (2024-2040), with only a slight decline to 1.0% in 2051-2060.

Figure 5 GDP Impact on Coal-fired Power Plant Sector



Source: Analysis of CORE Indonesia (2025)

The Coal Phase-down scenario presents a different trajectory, where CFPP's GVA reaches its peak at Rp 215.64 trillion in 2030 and then gradually declines as coal-fired power plant capacity is reduced, eventually reaching zero by 2055. This decline pattern reflects a more moderate transition away from coal-based power generation. The GDP contribution in this scenario starts strong at 1.2% during 2024-2030 but shows a steady decline thereafter, dropping to 1.0% in 2031-2040, 0.5% in 2041-2050, and reaching a minimal 0.1% in 2051-2060.

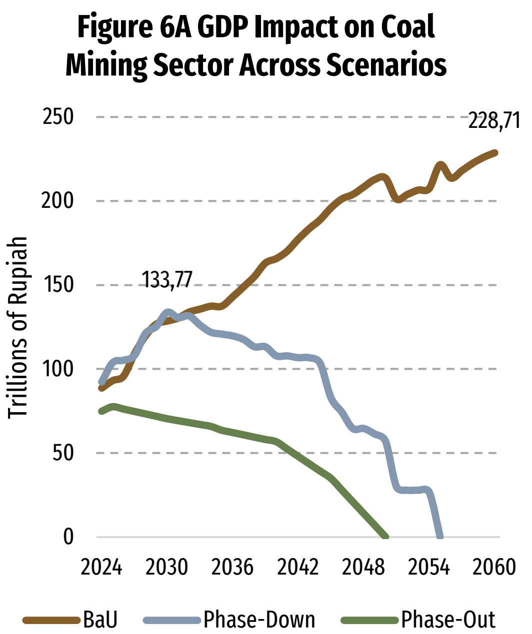
In contrast, the Coal Phase-out scenario demonstrates a more aggressive reduction in CFPP's GVA, reaching its peak earlier at Rp 202.59 trillion in 2025 before beginning a steady decline and completing the phase-out by 2050, which is five years earlier than the phase-down scenario. This accelerated transition is clearly reflected in the GDP contribution pattern, starting at 0.8% in 2024-2030, declining to 0.5% in 2031-2040, further reducing to 0.2% in 2041-2050, and reaching 0% by 2051-2060.

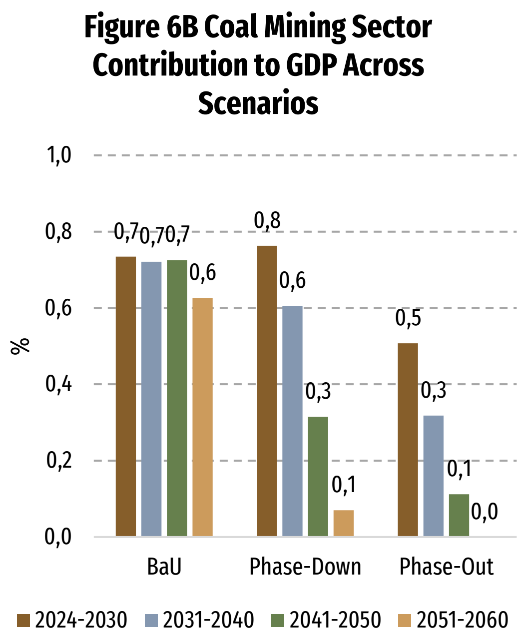
The time-period analysis reveals varying GVA and GDP contributions from CFPP across different decades. During 2024-2030, CFPP maintains relatively stable values across all scenarios, though with notable differences (1.2% in BaU and Phase-down versus 0.8% in Phase-out). However, the divergence becomes more pronounced in subsequent periods, with the starkest differences observed in 2041-2050, where the BaU scenario maintains high GVA levels and a stable GDP contribution of 1.2% while both phase-down and phase-out scenarios show significant reductions to 0.5% and 0.2% respectively. By 2051-2060, only the BaU scenario continues to generate substantial GVA from CFPP operations, maintaining a 1.0% GDP contribution, while the other scenarios approach or reach zero contribution.

2.2.2 GDP Impact on Coal Mining Sector

Looking at the GVA projections specifically for the coal mining sector in Indonesia, the Business as Usual (BaU) scenario shows a gradual upward trend, supporting higher installed capacity for CFPP input, with values reaching approximately Rp 228.71 trillion by 2060. The GDP contribution in this scenario remains relatively stable at 0.7% during 2024-2030 and 2031-2040, with a slight decline to 0.6% in 2051-2060, indicating economic significance under normal operating conditions.

Figure 6 GDP Impact on Coal Mining Sector





Source: Analysis of CORE Indonesia (2025)

In the Coal Phase-down scenario, the coal mining sector's GVA demonstrates a more moderate trajectory, reaching its peak in 2030 at Rp 133.77 trillion. While the sector maintains a strong 0.8% GDP contribution during 2024-2030, it experiences a notable decrease to 0.6% in 2031-2040, followed by a further reduction to 0.3% in 2041-2050. The decline continues until reaching just 0.1% by 2051-2060, reflecting a controlled reduction in coal mining activities over this period.

The Coal Phase-out scenario shows a more aggressive reduction, with the sector reaching its peak earlier in 2025 at Rp 77.56 trillion. The GDP contribution starts at 0.5% during 2024-2030, dropping to 0.3% in 2031-2040, and declining further to 0.1% in 2041-2050 before reaching zero by 2050, five years ahead of the phase-down scenario. This earlier peak and steeper decline reflect a more accelerated transition away from coal mining activities.

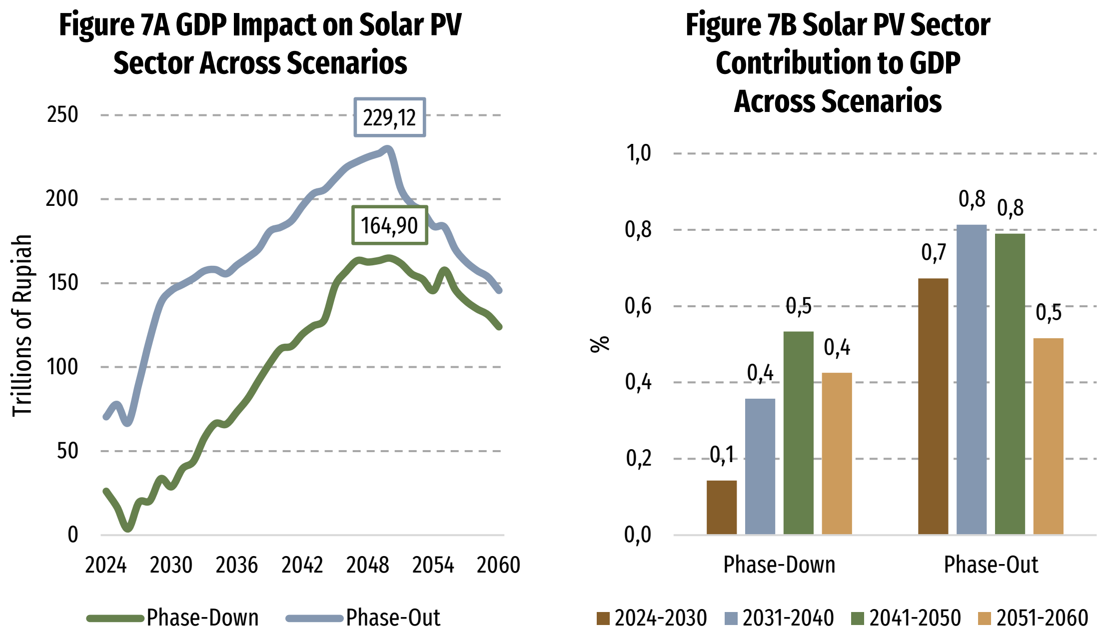
The decadal analysis reveals that during 2024-2030, coal mining GVA remains relatively robust across all scenarios, though with varying intensities (0.7% in BaU, 0.8% in Phase-down, and 0.5% in Phase-out). However, the differentiation becomes more evident in subsequent decades, particularly during 2041-2050, where the BaU scenario maintains a steady 0.7% contribution while both phase-down and phase-out scenarios exhibit marked decreases to 0.3% and 0.1% respectively. The final period of 2051-2060 shows the complete cessation of GVA from coal mining in the phase-out scenario, a minimal 0.1% contribution in the phase-down scenario, while the BaU scenario continues to generate 0.6% GDP contribution from mining operations.

2.3 Study Case: Projection of Solar Photovoltaic Development Impact on GDP

2.3.1 GDP Impact on Solar Photovoltaic Sector

Based on the analysis from CORE Indonesia (2025) (see Figure 7), the GDP impact of the Solar PV sector in Indonesia shows distinct patterns across two scenarios: Phase-Down and Phase-Out. The Phase-Out scenario shows higher impact because, as discussed in the previous sub-section, it involves a more aggressive retirement schedule for coal-fired power plants (PLTU) compared to the Phase-Down scenario. Consequently, it is assumed that the need for replacement power generation capacity would also be higher, leading to a peak GDP impact of Rp 229.12 trillion around 2048, significantly higher than the Phase-Down scenario which peaks at Rp 164.90 trillion.

Figure 7 GDP Impact on Solar PV Sector



Source: Analysis of CORE Indonesia (2025)

Looking at the contribution of the Solar PV sector to GDP across different time periods reveals an interesting pattern in both scenarios. In the Phase-Down scenario, the contribution starts at 0.1% during 2024-2030, increases to 0.4% in 2031-2040, peaks at 0.5% in 2041-2050, and slightly decreases to 0.4% in 2051-2060. The Phase-Out scenario shows consistently higher contributions, starting at 0.7% in 2024-2030, reaching 0.8% in both 2031-2040 and 2041-2050 periods, before declining to 0.5% in 2051-2060.

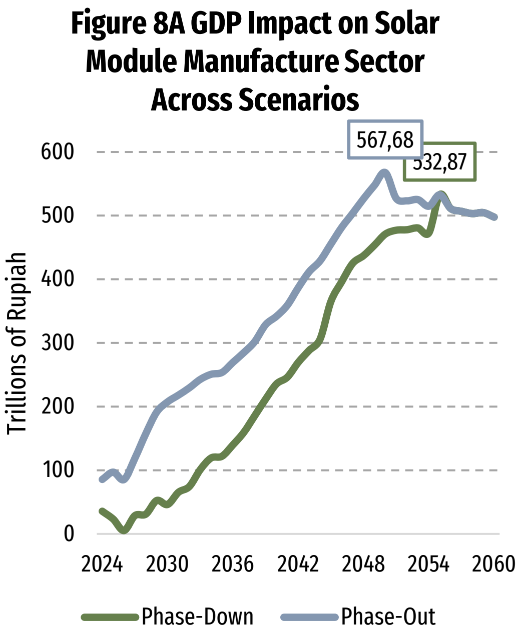
The declining trend observed in later years is attributed to the model's limitation. This suggests that the actual potential for Solar PV's contribution to GDP could be higher if broader electricity demand growth not included in this analysis were also to be met by Solar PV installations. Conversely, the GDP contribution from solar PV would be lower if the high electricity demand from retired coal power plants were to be replaced by alternative power generation sources.

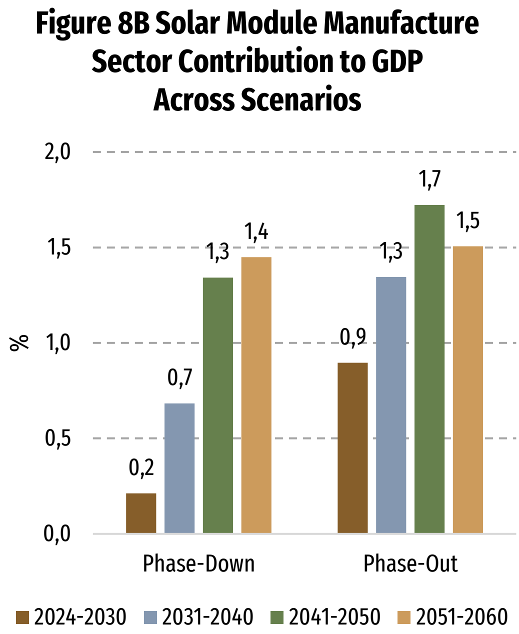
2.3.2 GDP Impact on Solar Module Manufacture Sector

Based on the analysis from CORE Indonesia (2025) (see Figure 8), the GDP impact of the Solar Module Manufacture sector in Indonesia demonstrates distinct patterns across two scenarios: Phase-Down and Phase-Out. The Phase-Out scenario shows a higher impact because it involves a more aggressive retirement schedule for coal-fired power plants (PLTU) compared to the Phase-Down scenario. Consequently, it is assumed that the need for replacement power generation capacity would also be higher, which naturally leads to greater demand for solar module supply, resulting in a peak GDP impact of Rp 567.68

trillion around 2054, compared to the Phase-Down scenario which peaks at Rp 532.87 trillion.

Figure 8 GDP Impact on Solar Module Manufacture Sector





Source: Analysis of CORE Indonesia (2025)

The sector's contribution to GDP follows a similar pattern but provides additional insights into the economic significance of solar manufacturing. In the Phase-Out scenario, the contribution starts robustly at 0.9% during 2024-2030 and reaches 1.5% by 2051-2060, reflecting the accelerated transition. The Phase-Down scenario, while starting lower at 0.2%, shows steady growth reaching a peak of 1.7% during 2041-2050 before settling at 1.5% in 2051-2060. This analysis suggests that the actual potential for Solar Module Manufacture's contribution to GDP could be even higher if broader electricity demand growth, which is not included in this analysis, were also to be met by solar power.

It's worth noting that these economic benefits are heavily dependent on domestic manufacturing capacity. The high demand for solar power installations is supported by domestically produced solar module spare parts, creating significant added value for Indonesia's economy. However, these GDP contributions would be substantially lower if the high demand for solar power to replace retired coal-fired power plants were met through imported solar modules rather than domestic manufacturing, highlighting the strategic importance of developing and maintaining a robust domestic solar manufacturing industry to maximize economic benefits from the energy transition.

2.3.3 GDP Impact on Battery Manufacture Sector

From the figure below, Indonesia's battery manufacturing sector reveals compelling economic trajectories under both Phase-Down and Phase-Out scenarios. The Phase-Out pathway exhibits stronger performance, driven by its more ambitious timeline for coal power plant (PLTU) retirement. This accelerated transition necessitates greater deployment of Battery Energy Storage System (BESS) infrastructure to complement renewable energy systems, pushing the sector's GDP contribution to reach Rp 26.46 trillion by 2048, while the Phase-Down approach achieves a more modest peak of Rp 22.45 trillion.

Figure 9 GDP Impact on Battery Manufacture Sector

Figure 9A GDP Impact on Battery Manufacture Sector Across Scenarios

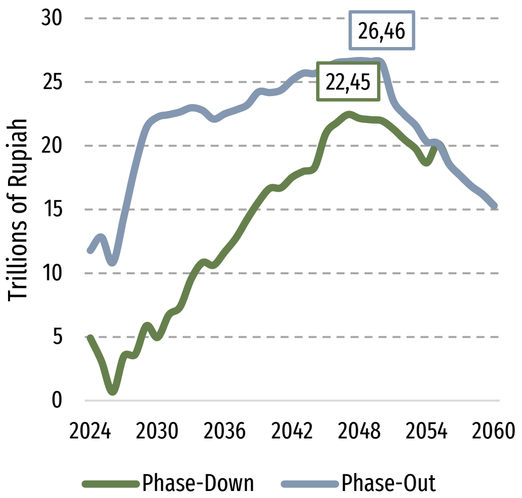
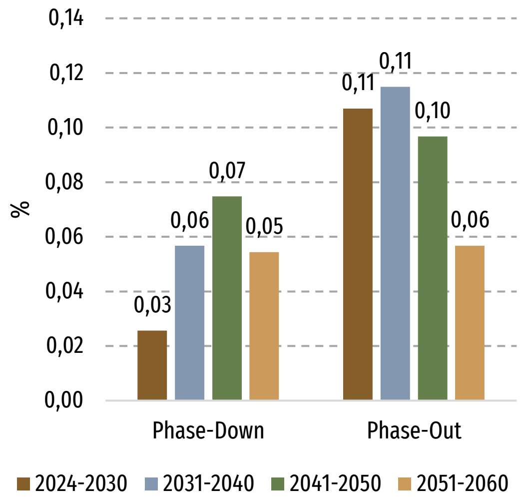


Figure 9B Battery Manufacture Sector Contribution to GDP Across Scenarios



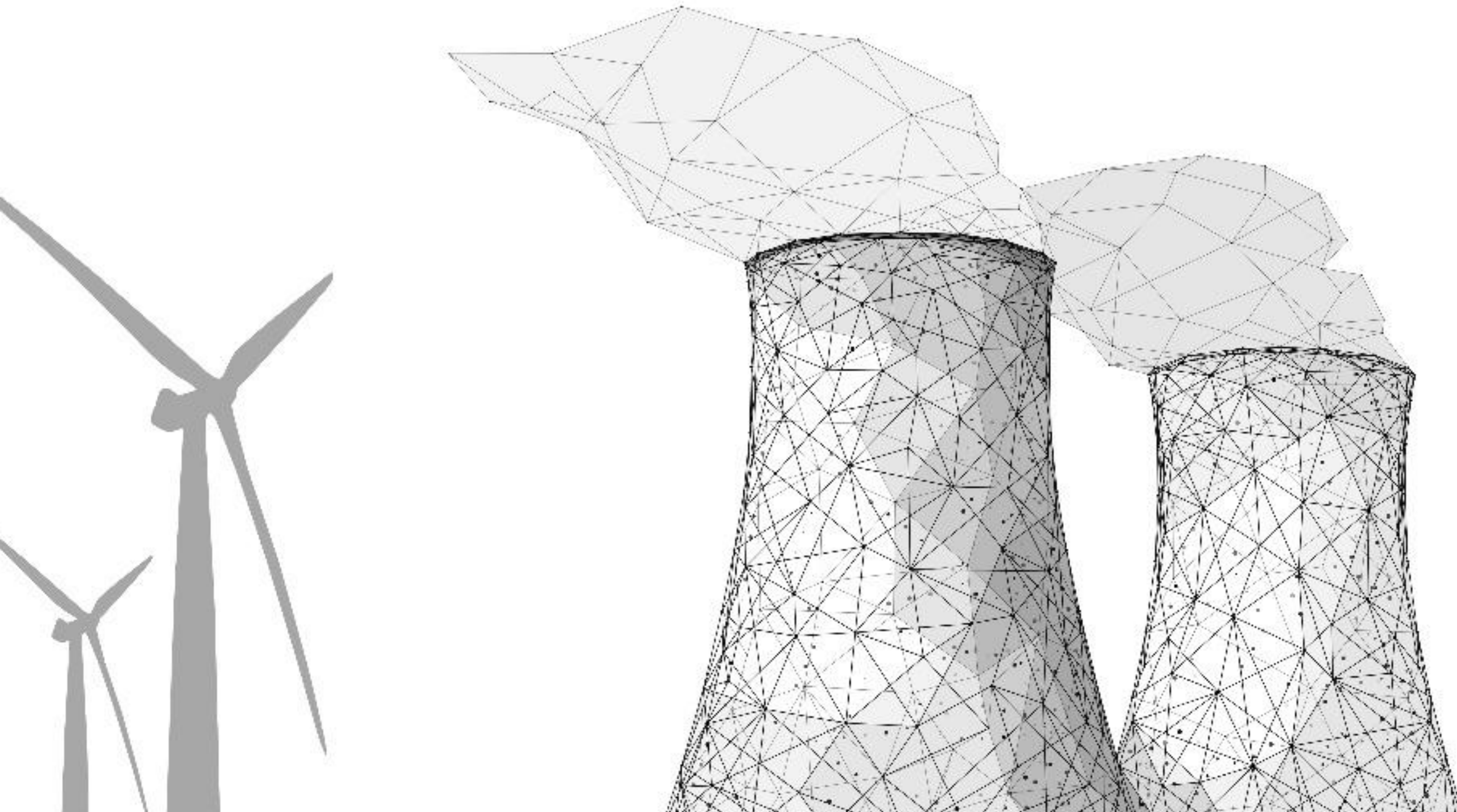
Source: Analysis of CORE Indonesia (2025)

The sectoral GDP contribution graphs illustrated above, highlight interesting temporal dynamics. Under the Phase-Out framework, the battery industry maintains a robust presence, accounting for 0.11% of GDP in the initial period (2024-2030) and sustaining similar levels through mid-century before tapering to 0.06% in the final decade. In contrast, the Phase-Down pathway depicts a more gradual evolution, beginning at 0.03% and climbing steadily to 0.07% by 2041-2050, followed by a modest decline to 0.05% in the closing period.

Indonesia's economic potential in BESS depends on its local manufacturing capacity. As renewable energy use grows, so does the demand for BESS, offering opportunities for domestic industry. However, relying on imports instead of local production could reduce these benefits, highlighting the need to strengthen national battery manufacturing.

CHAPTER III

FISCAL IMPACTS OF EARLY COAL POWER PLANT RETIREMENT IN INDONESIA



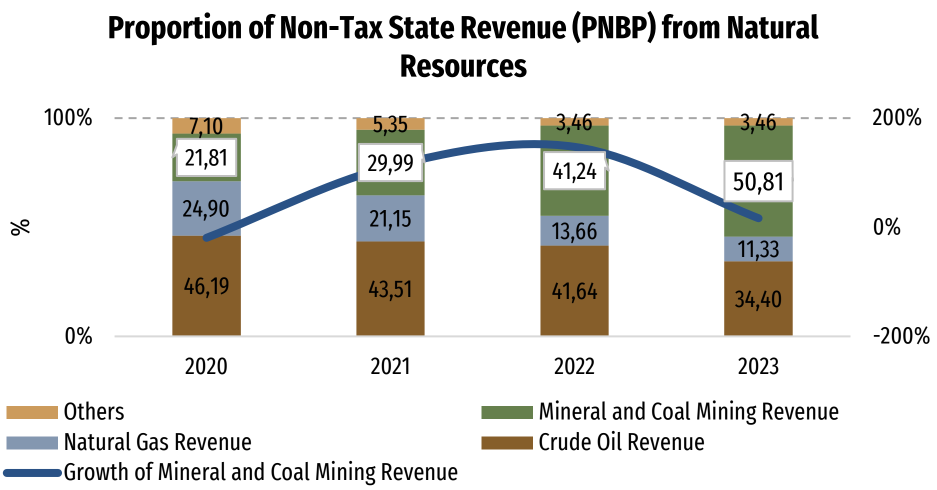
3.1 Current Condition of Fiscal in the Coal-Related Sector

Coal power plants play a significant role in Indonesia's energy landscape, contributing not only to electricity generation but also to economic activity. However, their fiscal impact is complex, involving government revenues from coal mining, subsidies for coal-based electricity, and broader macroeconomic implications. A review of global literature on the fiscal impacts of coal power plants suggests a dual effect: while these facilities generate substantial government revenues, they also impose long-term financial burdens through environmental externalities, subsidies, and infrastructure maintenance costs (OECD, 2019; Coady et al., 2019). These dynamics are particularly evident in Indonesia, where coal remains a dominant export commodity and a key driver of domestic energy supply, supported by abundant reserves and established infrastructure.

The fiscal contribution of coal mining comes from multiple revenue streams, including royalties, corporate income taxes, export earnings, and regional revenue sharing. Mining companies pay royalties ranging from 5% to 13.5% of the selling price based on Government Regulation No. 26 of 2022 concerning Types and Tariffs of Non-Tax State Revenue (PNBP) applicable to the Ministry of Energy and Mineral Resources (ESDM), alongside land and building taxes and non-tax state revenue (PNBP).

In 2023, the total Non-Tax State Revenue (PNBP) from natural resources (SDA) was recorded at Rp 254.2 trillion, with the largest contribution coming from the mining sector, which reached Rp 129.1 trillion. This means that the mining sector contributed approximately 50.8% of the total SDA revenue, highlighting its dominance in the country's natural resource income. Compared to the total PNBP, which amounted to Rp 612.54 trillion, the mining sector's PNBP accounted for around 21.1%, reaffirming its position as one of the main contributors to PNBP. Moreover, 85% of the mining sector's SDA PNBP revenue came from coal.

Figure 10 Proportion of Top 3 Non-Tax State Revenue from Natural Resources



Source: Adapted from Ministry of Finance (2025)

Additionally, coal exports generate foreign exchange earnings, though policies such as the Domestic Market Obligation (DMO) influence overall revenue generation. While these revenues contribute to national and regional budgets, their long-term sustainability is uncertain. Fluctuating global coal prices, increasing domestic consumption, and growing investment in renewable energy alternatives have led to a gradual decline in coal's fiscal contribution. Similar trends have been observed globally, where economies transitioning to sustainable energy face fiscal vulnerabilities, particularly in resource-dependent regions (Braithwaite & Gerasimchuk, 2019; IMF, 2020).

At the same time, Indonesia's dependence on coal extends beyond mining revenues to electricity generation. The state-owned electricity company, PLN, heavily relies on coal-fired power plants to meet energy demand. To maintain affordable electricity prices, the government provides subsidies for coal-based electricity, often creating a net fiscal burden. While coal consumption generates VAT revenue, preferential pricing policies and regulatory constraints limit the overall fiscal balance. Moreover, PLN receives financial support from the government, both through direct subsidies and indirect incentives such as fuel price adjustments. International experiences indicate that as countries phase out coal, reallocated subsidies towards renewable energy can ease long-term fiscal pressures (Laan et al., 2021; World Bank, 2020).

Given these fiscal and environmental challenges, transitioning to renewable energy sources is becoming increasingly critical. Among various alternatives, solar power (PLTS) presents a particularly viable solution due to its declining technology costs and minimal environmental impact. Studies suggest that greater adoption of solar energy can reduce dependence on fossil fuels while creating new economic opportunities, particularly in job creation within the renewable energy sector (IRENA, 2020). Furthermore, expanding solar power aligns with Indonesia's commitment to achieving a 23% renewable energy share by 2030, as outlined in the National Energy Policy (KEN).

While Indonesia has made progress in PLTS adoption, several challenges remain. Regulatory frameworks, financing mechanisms, and grid integration issues continue to hinder large-scale implementation. To address these challenges, the government has introduced incentives such as feed-in tariffs and net metering policies, but their application has been uneven. Although industrial and commercial sectors have increasingly integrated solar energy into their operations, residential adoption remains limited due to high upfront costs and lack of awareness (MEMR, 2022).

3.2 Projection of Early Coal Power Plant Retirement Impact on Fiscal

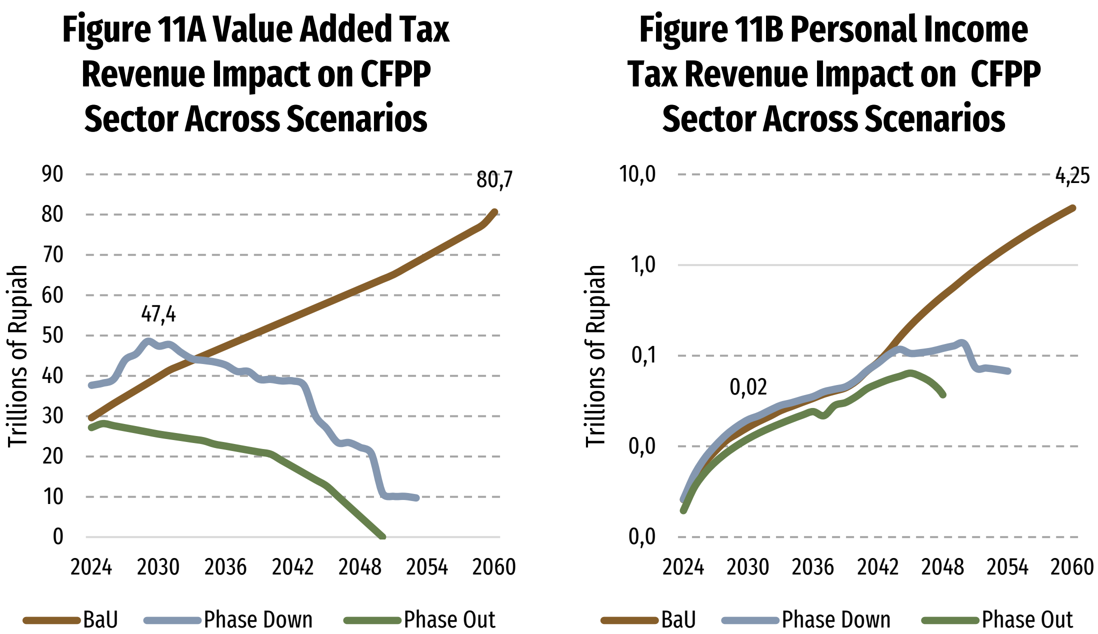
The fiscal impact analysis of the early retirement of coal-fired power plants (CFPP) is estimated across two key sectors: the coal mining sector and the coal-fired power plant sector. This study evaluates the fiscal implications under three scenarios: Business as

Usual (BaU), Coal Phase-Down, and Coal Phase-Out. This analysis aims to understand how the early retirement policy of coal-fired power plants may impact state revenue, both in terms of income from the coal mining sector and revenue generated from CFPP operations.

3.2.1 Fiscal Impact on Coal-fired Power Plant Sector

The CFPP's sector has a significant fiscal impact on national revenue, primarily through Value-Added Tax (VAT), Corporate Income Tax (CIT) and Personal Income Tax (PIT). Meanwhile fiscal impact on spending primarily through subsidy. The fiscal impact of this sector can be projected under three scenarios: Business as Usual (BaU), where production and tax revenues continue to increase; Phase Down, where a gradual decline in fiscal contributions occurs; and Phase Out, which indicates a sharp reduction due to the progressive cessation of coal mining activities.

Figure 11 VAT and Personal Income Tax Revenue Impact on Coal-fired Power Plant Sector

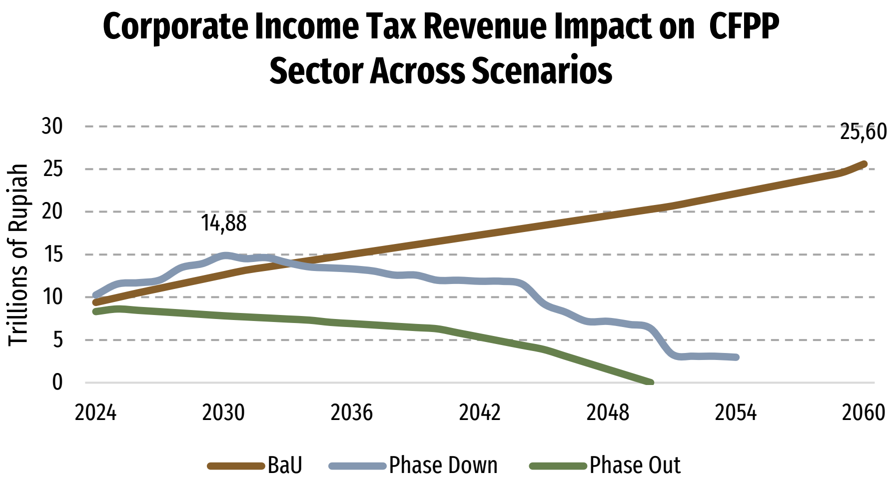


Source: Analysis of CORE Indonesia (2025)

Value Added Tax revenue from the Coal-Fired Power Plant sector shows dramatic divergence across scenarios. Under Business as Usual, revenue steadily climbs to Rp 80.7 trillion by 2060, while the Phase-Down scenario peaks at Rp 47.4 trillion around 2030 before declining gradually after 2042 to approximately Rp 10 trillion by 2054. The Phase-Out scenario demonstrates the most aggressive reduction, reaching zero by 2050.

The second graph reveals smaller-scale Personal Income Tax (PIT) impacts on what appears to be a CFPP subsector. While BAU shows exponential growth to Rp 4.25 trillion by 2060, both transition scenarios peak at only Rp 0.02 trillion around 2042 before declining, with Phase-Out dropping to zero by 2048 and Phase-Down extending slightly longer until 2054.

Figure 12 Corporate Income Tax Revenue on CFPP Sector



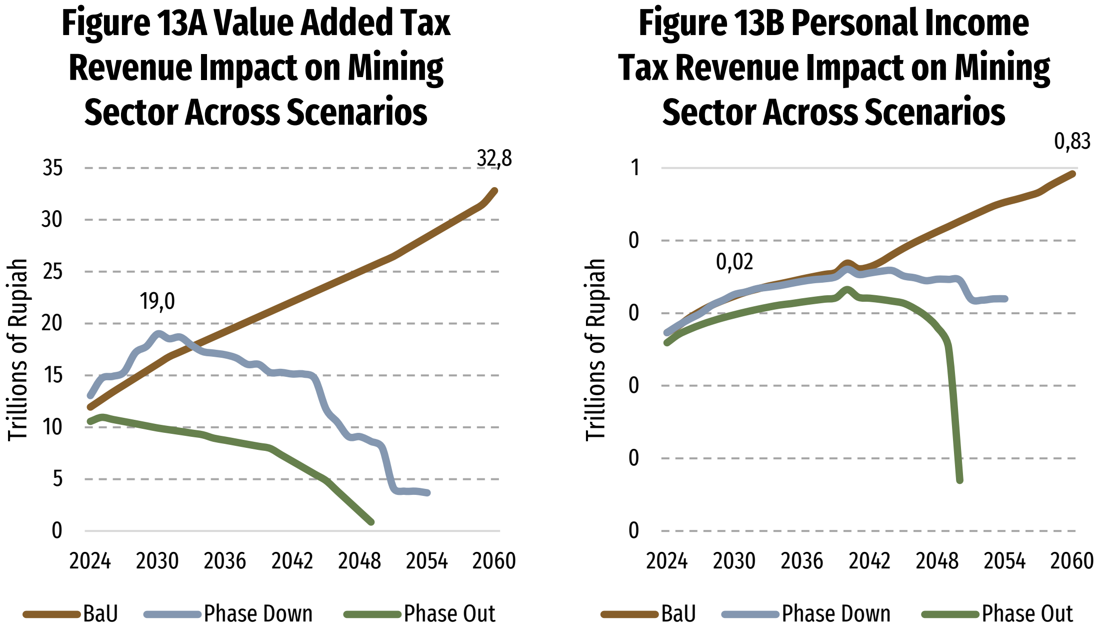
Source: Analysis of CORE Indonesia (2025)

The Corporate Income Tax (CIT) revenue impact on the CFPP sector displays distinct trajectories across the three scenarios. Under BaU conditions, CIT revenue shows consistent growth from approximately Rp 10 trillion in 2024 to Rp 25.6 trillion by 2060, reflecting uninterrupted sector expansion. In contrast, the Phase-Down scenario initially increases to peak at Rp 14.88 trillion around 2030, maintains relative stability until 2042, then experiences a stepped decline, ultimately dropping to about Rp 3 trillion by 2054. The Phase-Out scenario demonstrates the most aggressive revenue reduction pattern, showing a continuous downward trend from 2024 onward and reaching zero by 2050, highlighting the significant fiscal implications of an accelerated transition away from coal-fired power generation.

3.2.2 Fiscal Impact on Coal Mining Sector

The coal mining sector has a significant fiscal impact on national revenue, primarily through Value-Added Tax (VAT), Corporate Income Tax (CIT), Personal Income Tax (PIT), and Non-Tax State Revenue (PNBP) from royalties. VAT estimates reflect contributions from taxable coal sales transactions, while CIT represents the profits earned by companies operating in this sector. Meanwhile, PIT illustrates tax contributions from the workforce within the mining industry. Additionally, PNBP royalties constitute a crucial component of state revenue, calculated based on the volume and price of coal production. The fiscal impact of this sector can be projected under three scenarios: Business as Usual (BaU), where production and tax revenues continue to increase; Phase Down, where a gradual decline in fiscal contributions occurs; and Phase Out, which indicates a sharp reduction due to the progressive cessation of coal mining activities.

Figure 13 VAT and Personal Income Tax Revenue Impact on Coal Mining Sector

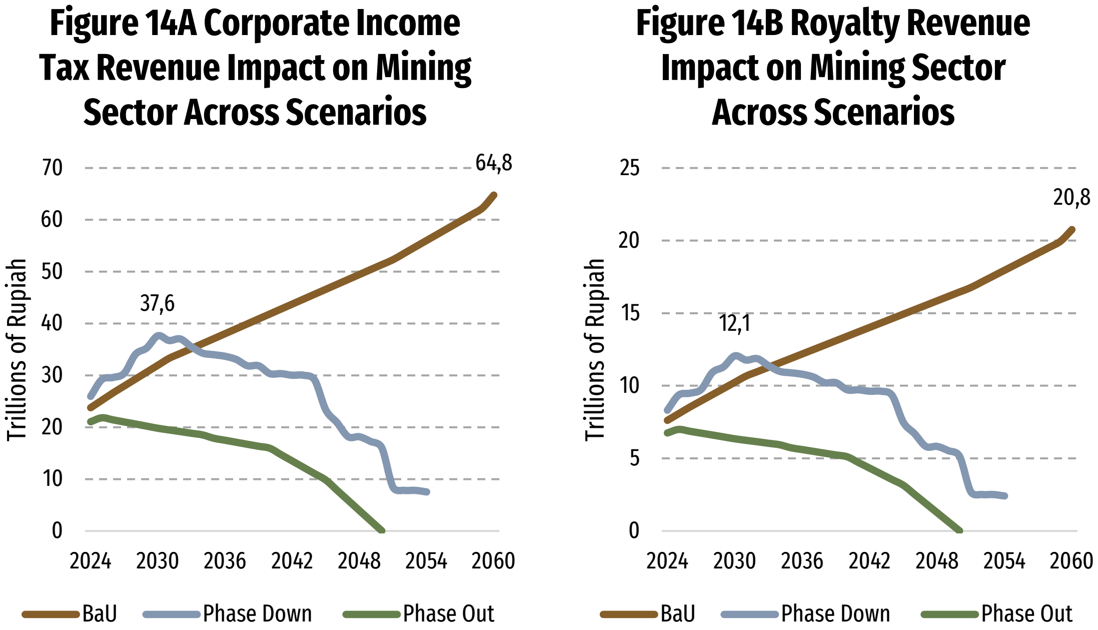


Source: Analysis of CORE Indonesia (2025)

The figure 13A illustrates the projected trend of Value-Added Tax (VAT) in the mining sector under three scenarios: Business as Usual (BaU), Phase Down, and Phase Out. In the BaU scenario, VAT revenue steadily increases, reaching 32.8 trillion rupiah by 2060. The Phase Down scenario exhibits an initial rise, peaking at 19.0 trillion rupiah around 2030, followed by a gradual decline until 2060. In contrast, the Phase Out scenario demonstrates a consistent downward trend from the outset, reflecting a significant reduction in mining activities, eventually nearing zero by 2060.

Figure 13B presents the projected Personal Income Tax (PIT) revenue from the mining sector under the same three scenarios. In the BaU scenario, PIT revenue consistently increases from 0 to 0.83 trillion rupiah by 2060, indicating stable industry growth. The Phase Down scenario shows an upward trend until approximately 2040, then stabilizes before experiencing a slight decline. Conversely, in the Phase Out scenario, PIT initially rises but undergoes a sharp drop after 2045, highlighting the fiscal impact of the gradual cessation of mining activities on individual tax contributions.

Figure 14 CIT and Royalty Revenue Impact on Mining Sector



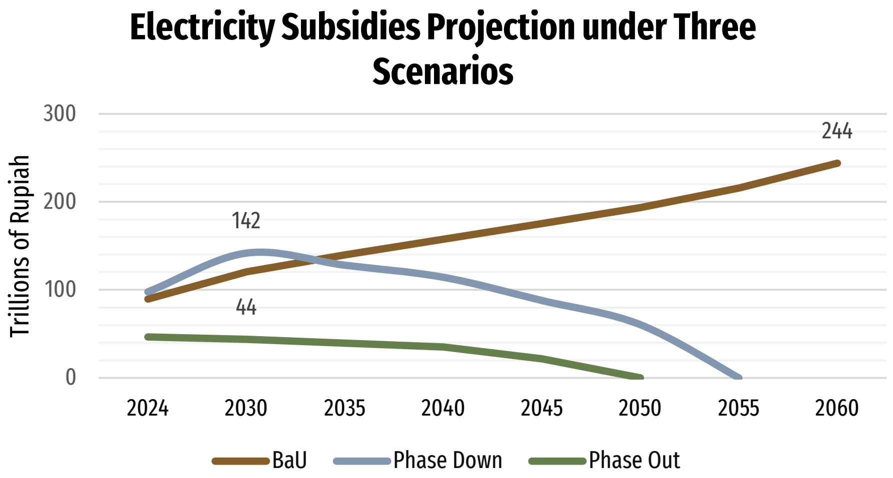
Source: Analysis of CORE Indonesia (2025)

The Phase Down scenario shows that state revenue is expected to peak between 2030 and 2036, before gradually declining until 2055. The most substantial decreases occur in Corporate and Individual Income Taxes, while VAT and Non-Tax Revenue Royalties also follow a downward trajectory. In the Phase Out scenario, the revenue decline is more abrupt, concluding by 2050, mirroring the pattern observed in the Phase Down scenario but on a smaller scale. This highlights that energy transition policies and the gradual phase-out of mining activities could have significant long-term implications for state revenue.

3.2.3 Fiscal Impact on Electricity Subsidies

The figure 15 shows the expected path of electricity subsidies in Indonesia from 2024 to 2060, measured in trillions of Rupiah. Under the Business as Usual (BaU) scenario, subsidies show a steady increase, rising from an average of 105 trillion rupiah annually during 2024-2030 to reaching 244 trillion rupiah by 2060. This is very different from the Phase-down scenario, which shows an initial increase, reaching its highest point during the 2041-2050 period at an average of 177 trillion rupiah per year, before falling sharply to 11.9 trillion rupiah in the 2051-2060 period.

Figure 15 Electricity Subsidies Projection



Source: Analysis of CORE Indonesia (2025)

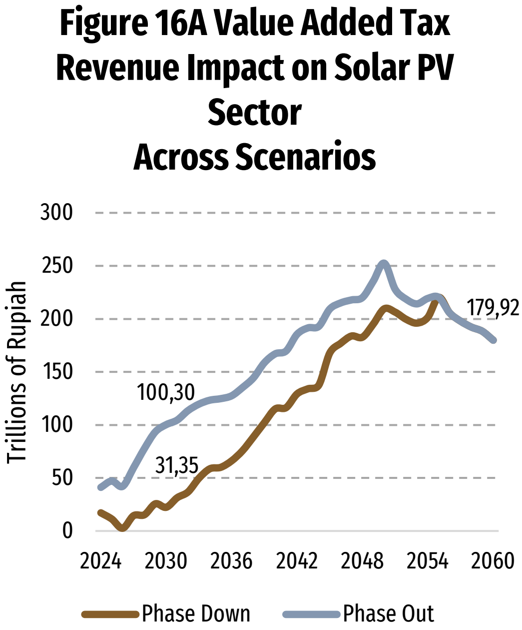
The most aggressive reduction plan is shown in the Phase-out scenario, which shows a steady decrease in electricity subsidies from an average of 46 trillion rupiah per year in the 2024-2030 period to zero by the 2051-2060 period. This scenario shows much greater and faster subsidy savings compared to the other two scenarios. The difference between the three paths becomes especially clear after 2035, with the BaU scenario continuing to rise while both alternative scenarios move toward significant reduction, though at different speeds and timeframes.

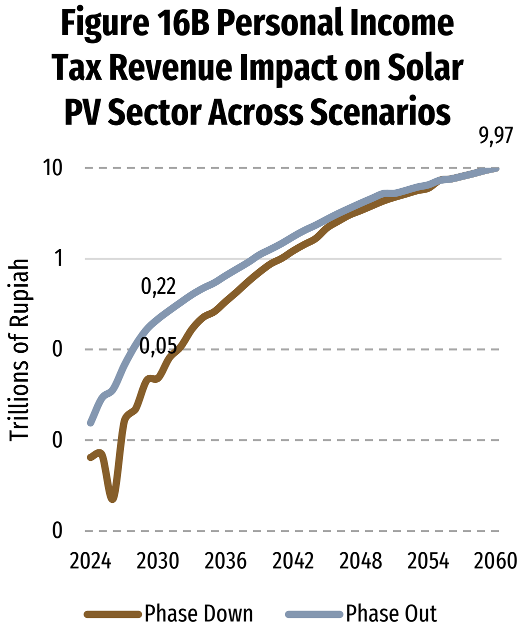
3.3 Study Case: Projection of Solar Photovoltaic Development Impact on Fiscal

3.3.1 Fiscal Impact on Solar Photovoltaic Sector

The solar photovoltaic sector has a significant fiscal impact on national revenue, primarily through Value-Added Tax (VAT), Corporate Income Tax (CIT), Personal Income Tax (PIT), and Non-Tax State Revenue (PNBP) from royalties. VAT estimates reflect contributions from taxable coal sales transactions, while CIT represents the profits earned by companies operating in this sector. Meanwhile, PIT illustrates tax contributions from the workforce within the mining industry. Additionally, PNBP royalties constitute a crucial component of state revenue, calculated based on the volume and price of coal production.

Figure 16 VAT and Personal Income Tax Revenue Impact on Solar PV Sector



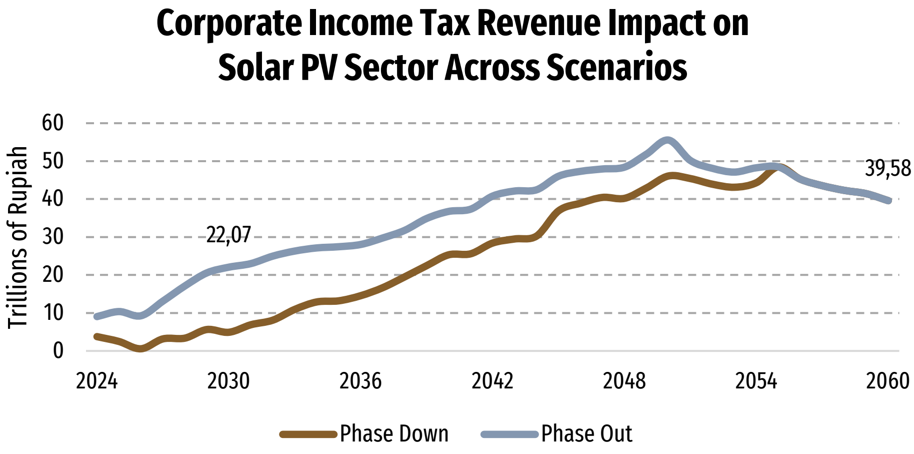


Source: Analysis of CORE Indonesia (2025)

The VAT Revenue Impact on the Solar PV Sector graph illustrates the projected trends in Value-Added Tax (VAT) revenue under two scenarios: Phase Down and Phase Out. In the Phase Out scenario, VAT revenue experiences significant growth, surpassing Rp 100.30 trillion by 2030, peaking at approximately Rp 250 trillion, and then gradually declining towards 2060. This indicates a rapid transition away from conventional energy sources, leading to higher investments in solar PV and increased taxable transactions. Meanwhile, the Phase Down scenario shows a more gradual rise in VAT revenue, reaching Rp 179.92 trillion by 2060, reflecting a slower transition where traditional energy sources still play a role in the economy.

The Personal Income Tax Revenue Impact on the Solar PV Sector graph depicts projected personal income tax (PIT) revenues under the same two scenarios. In the Phase Out scenario, PIT revenue grows steadily, reaching Rp 9.97 trillion by 2060, indicating a robust expansion of employment and income in the solar PV sector. The Phase Down scenario follows a similar trajectory but at a slightly slower pace, with revenue reaching Rp 0.22 trillion by 2030 and continuing its upward trend. This suggests that while both scenarios support growth in employment and income generation, a faster transition to solar PV (Phase Out) results in a more significant long-term impact on tax revenue.

Figure 17 Corporate Income Tax Revenue Impact on Solar PV Sector



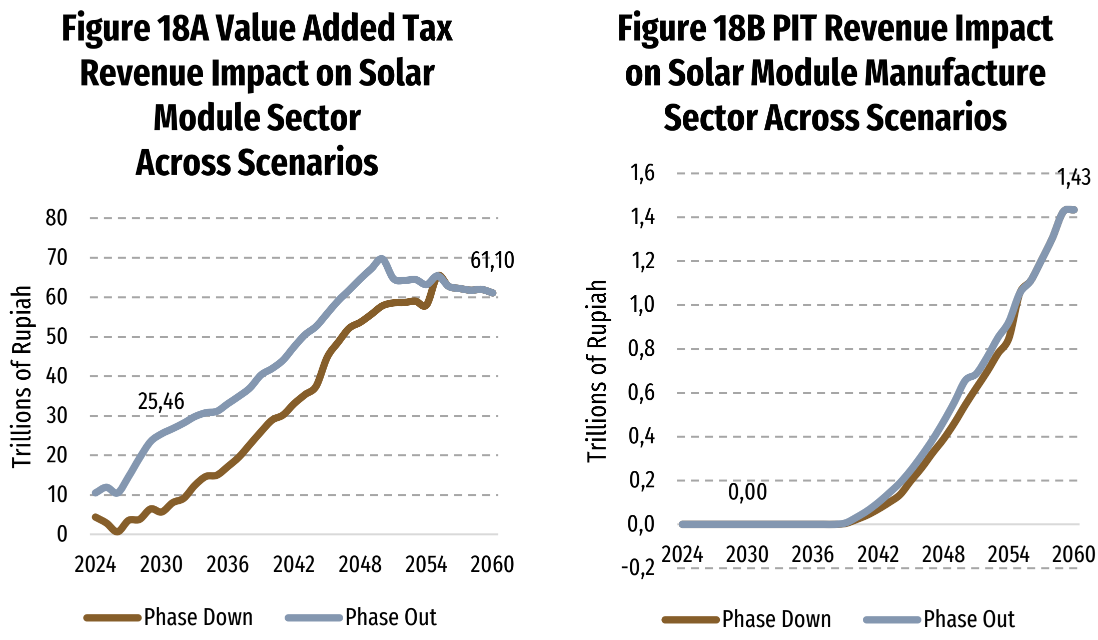
Source: Analysis of CORE Indonesia (2025)

The Corporate Income Tax revenue projections for the solar PV sector show parallel growth trends in both Phase Down and Phase Out scenarios from 2024 to 2060. The Phase Out scenario leads with higher values, reaching Rp 22.07 trillion by 2030 and peaking at approximately Rp 50 trillion around 2048, before settling at Rp 39.58 trillion in 2060. The Phase Down scenario follows a similar but more moderate growth pattern, maintaining a consistent gap below the Phase Out trajectory throughout the period, with both scenarios showing slight fluctuations but overall stable growth in the latter years of the projection.

3.3.2 Fiscal Impact on Solar Module Manufacture Sector

The solar modul manufacture sector has a significant fiscal impact on national revenue, primarily through Value-Added Tax (VAT), Corporate Income Tax (CIT), and Personal Income Tax (PIT). VAT estimates reflect contributions from taxable coal sales transactions, while CIT represents the profits earned by companies operating in this sector. Meanwhile, PIT illustrates tax contributions from the workforce within the mining industry. Additionally, PNBP royalties constitute a crucial component of state revenue, calculated based on the volume and price of coal production.

Figure 18 VAT and Personal Income Tax Revenue Impact on Solar Module Manufacture Sector

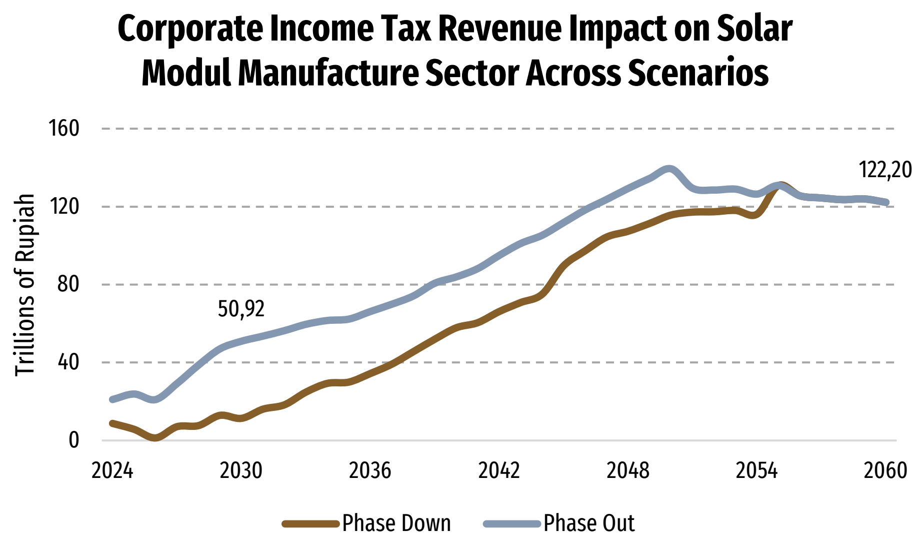


Source: Analysis of CORE Indonesia (2025)

The VAT revenue projections in the solar module sector demonstrate an upward trend across both scenarios from 2024 to 2060, with the Phase Out scenario reaching its peak at approximately Rp 61.10 Trillion in 2054 before experiencing a slight decline. The Phase Down scenario exhibits a more moderate yet consistent increase throughout the projected period.

Personal Income Tax revenue, both scenarios maintain relatively stable values near Rp 0 Trillion until 2039, followed by a sharp upward trajectory towards 2060, with the Phase Out scenario reaching Rp 1.43 Billions. This pattern suggests that the impact of income tax revenue will become substantially more significant in the long term, particularly post-2039, indicating a potential structural shift in the sector's tax contribution dynamics. The zero-revenue period through 2039 is attributable to average worker income in this sector remaining below the Rp 54 million annual threshold required for personal income taxation, with projections based on proxy data from average wages in the general manufacturing industry.

Figure 19 Corporate Income Tax Revenue Impact on Solar Modul Manufacture Sector



Source: Analysis of CORE Indonesia (2025)

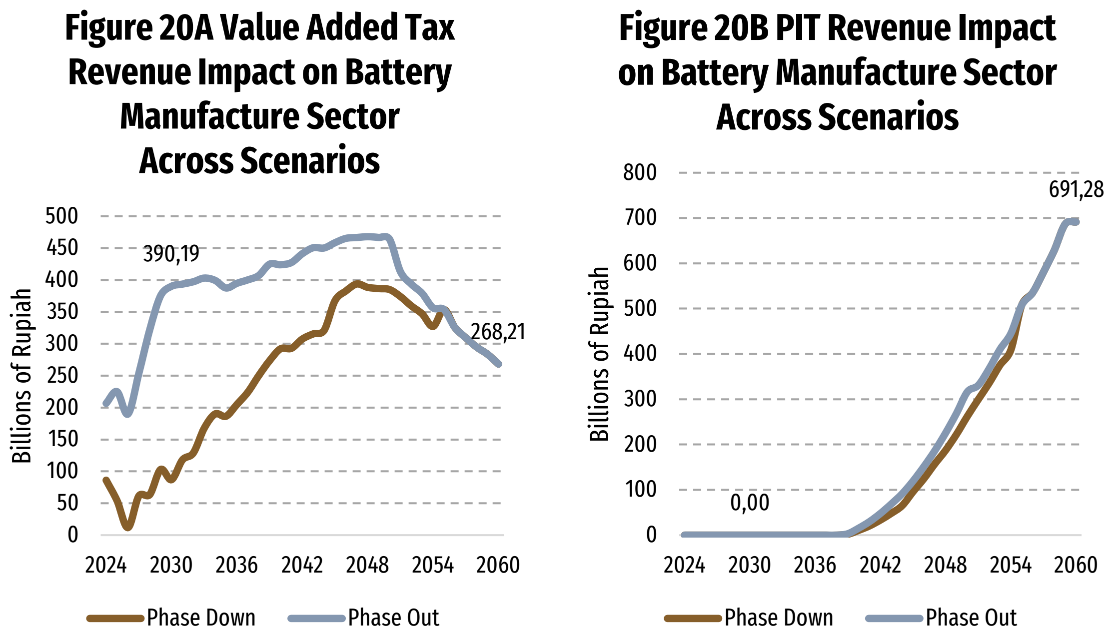
The Corporate Income Tax revenue projections for the solar module sector reveal distinct growth patterns across both Phase Down and Phase Out scenarios from 2024 to 2060. The Phase Out scenario demonstrates a more aggressive growth trajectory, reaching approximately Rp 50.92 Trillion in 2030 and continuing to rise until it peaks at around Rp 140 Trillion in 2048, before stabilizing at Rp 122.20 Trillion by 2060.

The Phase Down scenario exhibits a more conservative growth pattern, starting with lower values in the early years and gradually converging with the Phase Out scenario towards 2054. Both scenarios show sustained growth over the projected period, with the Phase Out scenario maintaining a consistently higher revenue trajectory throughout most of the timeframe. This trend suggests that corporate tax contributions from the solar module sector are expected to become increasingly significant, particularly in the medium to long term, regardless of the chosen policy scenario.

3.3.3 Fiscal Impact on Battery Manufacture Sector

The battery manufacture sector has a significant fiscal impact on national revenue, primarily through Value-Added Tax (VAT), Corporate Income Tax (CIT), and Personal Income Tax (PIT). VAT estimates reflect contributions from taxable coal sales transactions, while CIT represents the profits earned by companies operating in this sector. Meanwhile, PIT illustrates tax contributions from the workforce within the mining industry. Additionally, PNBP royalties constitute a crucial component of state revenue, calculated based on the volume and price of coal production.

Figure 20 VAT and Personal Income Tax Revenue Impact on Battery Manufacture Sector

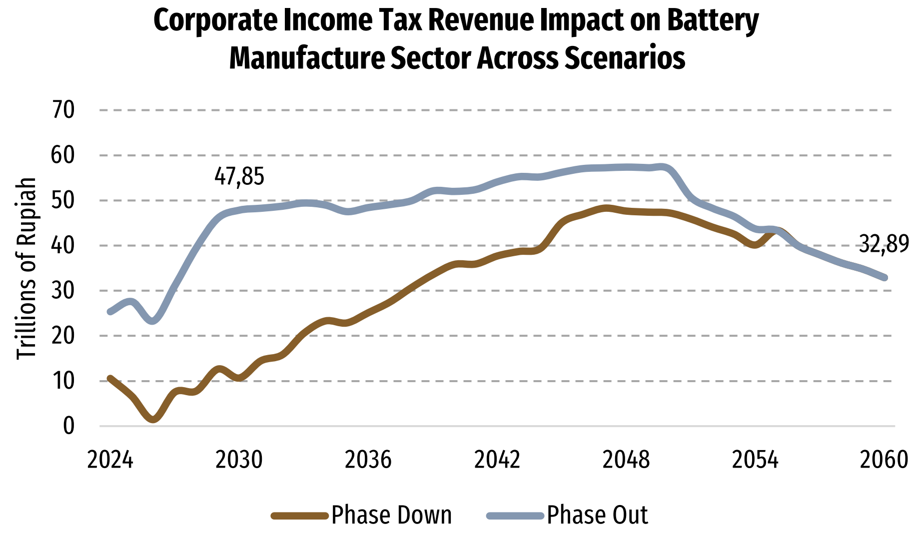


Source: Analysis of CORE Indonesia (2025)

The VAT revenue projections for the battery sector demonstrate distinct patterns across both scenarios from 2024 to 2060. The Phase Out scenario shows a sharp increase reaching Rp 390.19 billion in 2030, followed by steady growth until peaking at approximately Rp 450 trillion around 2048. However, it then experiences a significant decline, settling at Rp 268.21 billion by 2060. The Phase Down scenario exhibits a more gradual increase until 2048, followed by a similar declining trend, though maintaining a consistent gap below the Phase Out scenario throughout the projection period.

Personal Income Tax revenue impact on the battery manufacturing sector from 2024 to 2060 across two scenarios: Phase Down and Phase Out. Revenue remains at zero until 2038, as average worker income in this sector falls below the Rp 54 million annual threshold required for personal income taxation. The projection is based on proxy data from average wages in the general manufacturing industry, with the divergence between scenarios becoming most pronounced after 2054. After 2040, revenues begin to increase in both scenarios, with the Phase Out approach generating higher returns, reaching Rp 691.28 billion by 2060 compared to the Phase Down scenario which shows more modest growth. This substantial increase in personal income tax revenue post-2038 suggests a significant expansion in employment and income generation within the battery sector, particularly during the latter half of the projected period.

Figure 21 Corporate Income Tax Revenue Impact on Battery Manufacture Sector



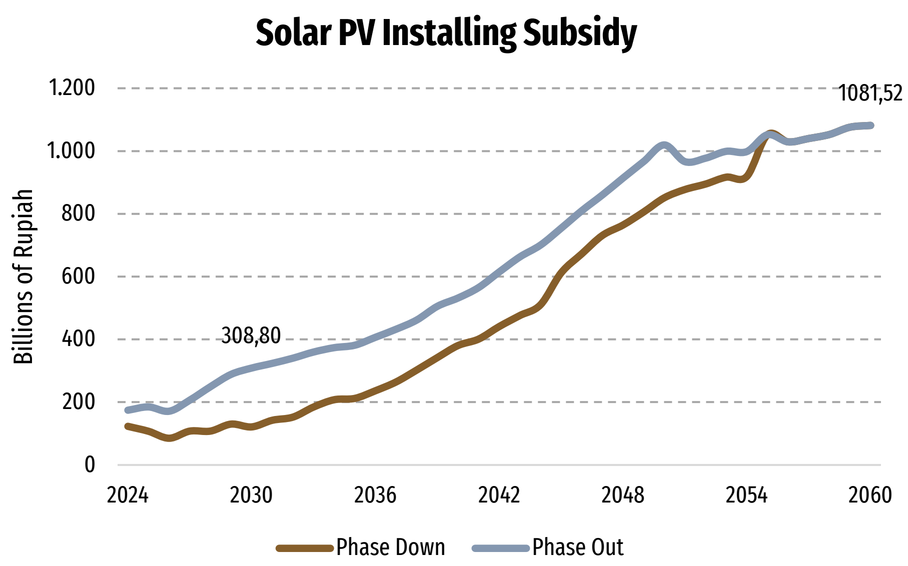
Source: Analysis of CORE Indonesia (2025)

Corporate Income Tax Revenue Impact on Battery Manufacture Sector Across Scenarios compares projected tax revenue from Indonesia's battery manufacturing sector from 2024 to 2060 under two scenarios. The Phase Out scenario shows faster early growth, reaching Rp 47.85 trillion by 2030 and maintaining higher values until around 2054. Meanwhile, the Phase Down scenario increases more gradually, peaking at approximately Rp 48 trillion around 2048-2050. By 2060, both scenarios converge, with Phase Out showing about Rp 32.89 trillion in tax revenue. This suggests that while Phase Out generates greater tax revenue initially, both approaches yield similar fiscal outcomes for the sector by the projection's end.

3.3.4 Fiscal Impact on Electricity Subsidy

The reallocation of reduced coal power plant (PLTU) subsidies towards solar PV installation represents a strategic shift in energy subsidy policy. Rather than directly subsidizing electricity tariffs, this approach channels funds into supporting the installation of solar photovoltaic systems at a rate of 10% of the tariff. This installation subsidy model promotes long-term renewable energy adoption while gradually reducing dependence on coal-generated electricity. By incentivizing initial setup rather than ongoing consumption, the policy aims to accelerate solar PV deployment and create sustainable energy infrastructure without perpetuating subsidy dependence.

Figure 22 Solar PV Installing Subsidy

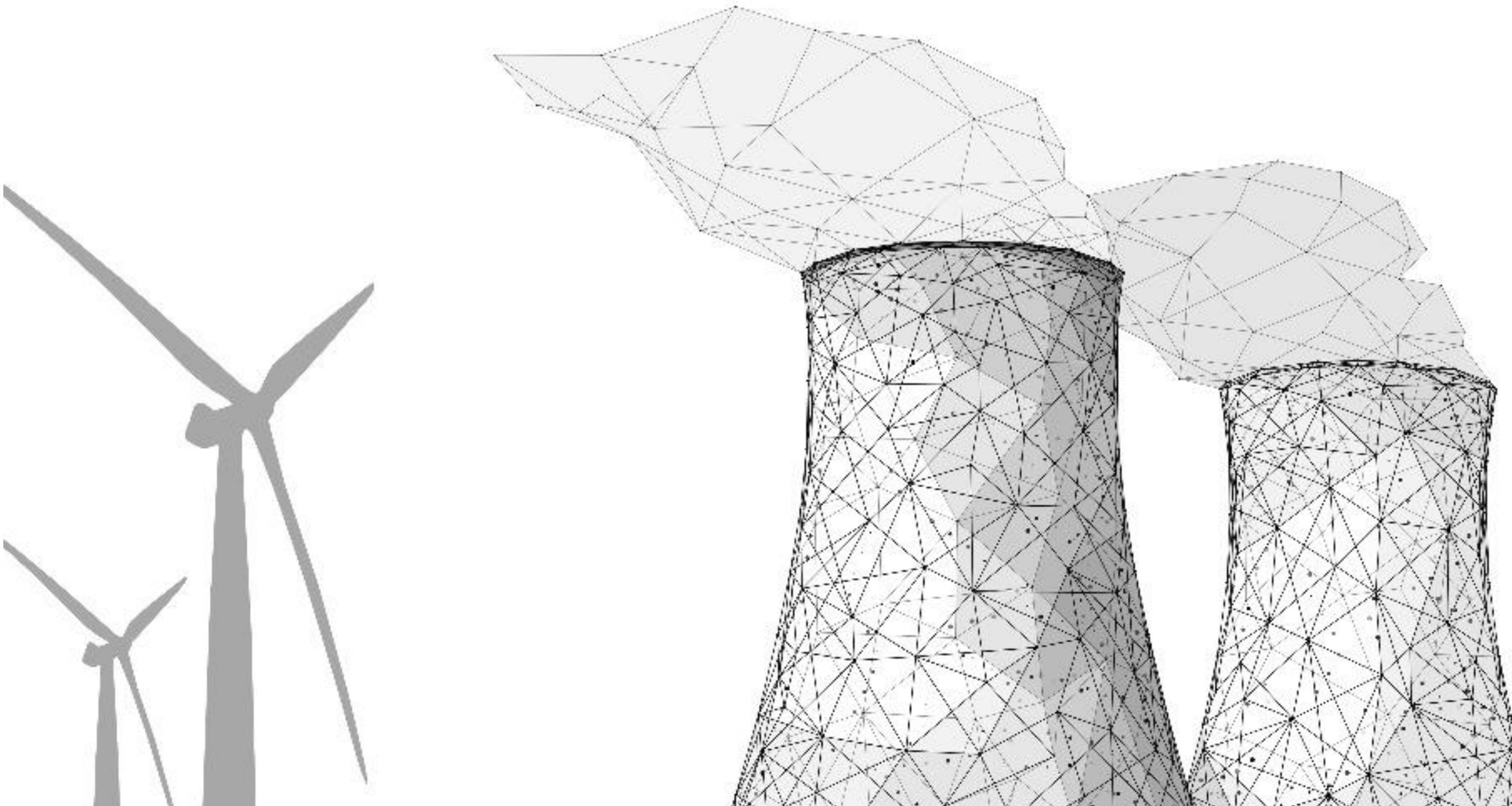


Source: Analysis of CORE Indonesia (2025)

The figure illustrates the projected financial allocation for solar PV installation subsidies from 2024 to 2060 under two scenarios. The orange line (Phase Out) represents a more aggressive subsidy reallocation approach compared to the blue line (Phase Down), with both scenarios showing a consistent upward trend. Starting from relatively modest subsidy levels of approximately Rp 100-200 billions in 2024, both scenarios demonstrate significant growth, particularly accelerating between 2036-2048, eventually reaching around Rp 1,000-1,100 billions by 2060. Notably, the Phase Out scenario consistently maintains higher subsidy levels throughout the projection period, reflecting its more ambitious approach to transitioning from coal power to solar energy infrastructure.

CHAPTER IV

EMPLOYMENT IMPACTS OF EARLY COAL POWER PLANT RETIREMENT IN INDONESIA



4.1 Current Condition of Employment in the Coal-Related Sector

Recent studies have provided comprehensive insights into the employment structure of Indonesia's coal industry. IESR (2022) identifies a distinctive pattern where mining service companies, including contractors, consultants, and various support services, account for 80-90% of total employment, reflecting companies' preference for flexible labor management.

Quantitative analyses of employment data reveal significant scale and regional variation. According to IESR (2022), while the coal industry's direct employment of 167,000 workers (as of 2020) represents less than 0.2% of national employment, its regional importance is substantial, particularly in provinces like East Kalimantan (11% of employment), South Sumatra (3%), and North Kalimantan (4%). When including all coal-related employment across the value chain, the total workforce reaches approximately 250,000 workers. Aprilia et al. (2019) found that despite regulatory requirements for 80% local employment in Berau regency, East Kalimantan, actual local employment reached only 40%. This finding contrasts with company sustainability reports claiming over 70% local employment, highlighting potential discrepancies in local employment reporting and implementation.

In examining the transition to clean energy, TransitionZero (2022) presents a comparative analysis of employment potential between coal and renewable energy sectors. Their research reveals that while coal power plants currently provide 1.3 jobs/MW (averaging 245 jobs per plant), renewable alternatives offer significantly higher employment intensity. Solar installations generate two jobs/MW, while wind installations create five jobs/MW, potentially creating 1,580 and 2,265 new jobs per installation respectively.

Based on findings of ILO (2022) the phase-out of coal-fired power plants potentially creates multidimensional impacts on Indonesia's workforce. It will directly affect approximately 1.4 million workers in the mining and quarrying sector, with over 50% possessing skills that are difficult to transfer to other sectors. Indirectly, the power plant phase-out will affect related industry value chains, including logistics (12.9% decline), sea transportation (10.9%), and railways (10.5%), as well as the power generation sector which currently relies on coal for 59% of its output. Regional impacts will be particularly severe in areas such as East Kalimantan, where 31.5% of its Gross Regional Domestic Product depends on coal. Studies on local employment implementation reveal compliance challenges.

However, TransitionZero (2022) identifies three critical challenges in this transition, particularly for the upstream mining sector's 250,000 workers: the geographical concentration of mining activities in specific communities, the immediate nature of job losses versus the gradual development of new opportunities, and the educational misalignment between current workers' skills and emerging green sector requirements.

These challenges are compounded by economic impact analyses from Fatah (2008) and Hilmawan et al. (2016), which demonstrate that coal mining generates relatively low value-added per output, limited employment opportunities, and high economic leakage compared to other sectors.

The informal mining sector adds another layer of complexity to the transition challenge. IESR (2022) documents 55 unlicensed mining operations in the Tanjung Enim Mining Unit area alone, highlighting the significance of informal employment in the sector and its implications for transition planning. This suggests that the actual scope of employment impact may be broader than official statistics indicate, requiring comprehensive transition strategies that address both formal and informal sector workers.

4.2 Projection of Early Coal Power Plant Retirement Impact on Employment

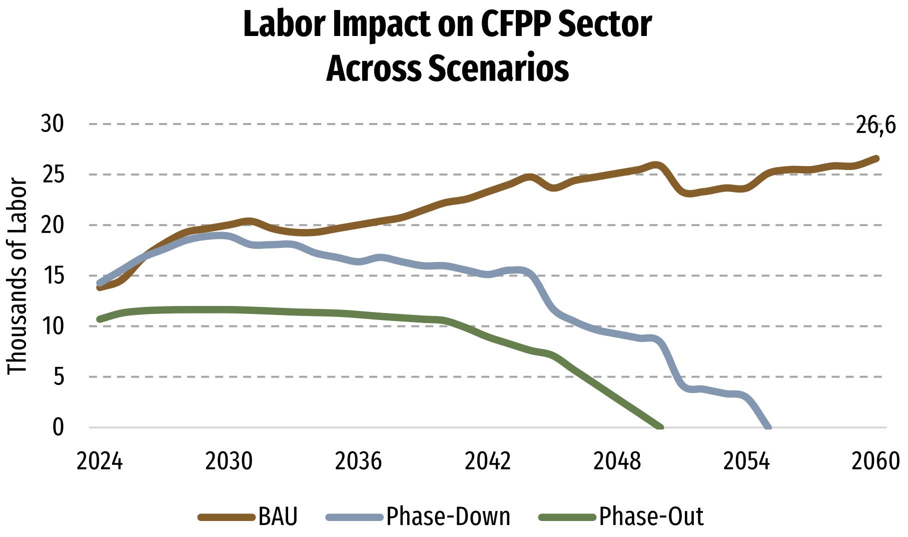
4.2.1 Employment Impact on Coal-fired Power Plant Sector

Based on the graph, employment impact projections in the coal-fired power plant (CFPP) sector demonstrate three distinct scenarios extending to 2060. Under the Business as Usual (BAU) scenario, the workforce is projected to increase steadily from approximately 14,000 workers in 2024 to 26,600 workers by 2060, reflecting sustained growth in the CFPP sector without restrictive policies.

The Phase-Down scenario presents a more moderate approach, maintaining approximately 20,000 workers until 2036, followed by a gradual decline. A significant decrease begins in 2042, continuing until reaching zero by 2060. This pattern represents a strategic and measured reduction in CFPP operations, allowing for an extended adaptation period for the workforce.

\Meanwhile, the Phase-Out scenario demonstrates the most aggressive approach. Beginning at the same level in 2024, the number of workers experiences a consistent decline, reaching zero more rapidly by 2048. This indicates an accelerated transition away from coal dependency.

Figure 23 Labor Impact on Coal-fired Power Plant Sector

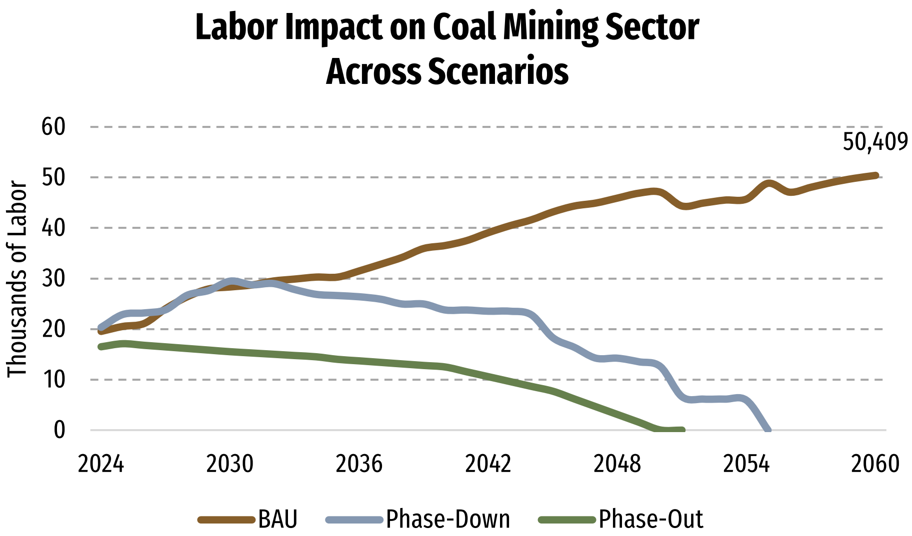


Source: Analysis of CORE Indonesia (2025)

4.2.2 Employment Impact on Coal Mining Sector

The graph below illustrates employment projections in the coal mining sector across three scenarios extending to 2060. Under the Business as Usual (BAU) scenario, employment increases significantly from approximately 20,000 workers in 2024 to 50,409 workers by 2060, demonstrating sustained expansion of mining activities without policy intervention.

Figure 24 Labor Impact on Coal Mining Sector



Source: Analysis of CORE Indonesia (2025)

The Phase-Down scenario exhibits a moderate reduction approach. Employment levels maintain stability at around 30,000 workers until 2036, followed by a gradual decline. A significant decrease commences in 2042, with employment ultimately reaching zero by 2060. This represents a measured reduction in mining operations, allowing an extended adaptation period for workforce transition. The Phase-Out scenario demonstrates the most aggressive reduction strategy. Beginning from similar employment levels in 2024, the workforce steadily declines, reaching zero by 2048. This accelerated approach indicates a more rapid transition away from coal mining activities.

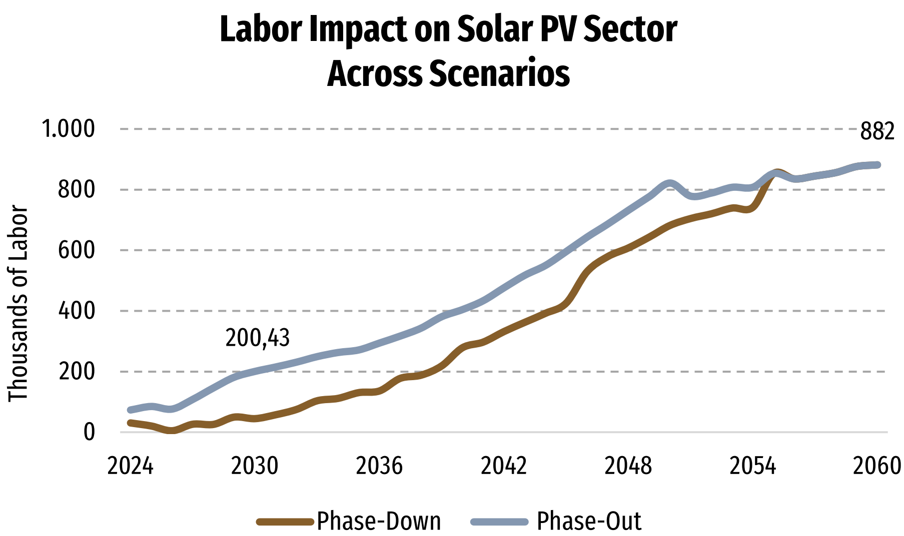
In comparison with the coal-fired power plant sector analysis, the coal mining sector exhibits higher initial employment figures and steeper decline curves in both transition scenarios, suggesting more substantial socio-economic implications.

4.3 Study Case: Projection of Solar Photovoltaic Development Impact on Employment

4.3.1 Employment Impact on Solar Photovoltaic Sector

The graph below illustrates employment projections for the solar photovoltaic (PV) sector across two scenarios: Phase-Out and Phase-Down.

Figure 25 Labor Impact on Solar PV Sector



Source: Analysis of CORE Indonesia (2025)

In the Phase-Out scenario, employment growth accelerates rapidly, beginning with approximately 100,000 workers in 2024 and reaching 200,430 workers by 2030. Growth continues steadily, achieving approximately 800,000 workers by 2048, and ultimately reaching 882,000 workers by 2060. This accelerated growth aligns with the expedited transition from coal-fired power generation.

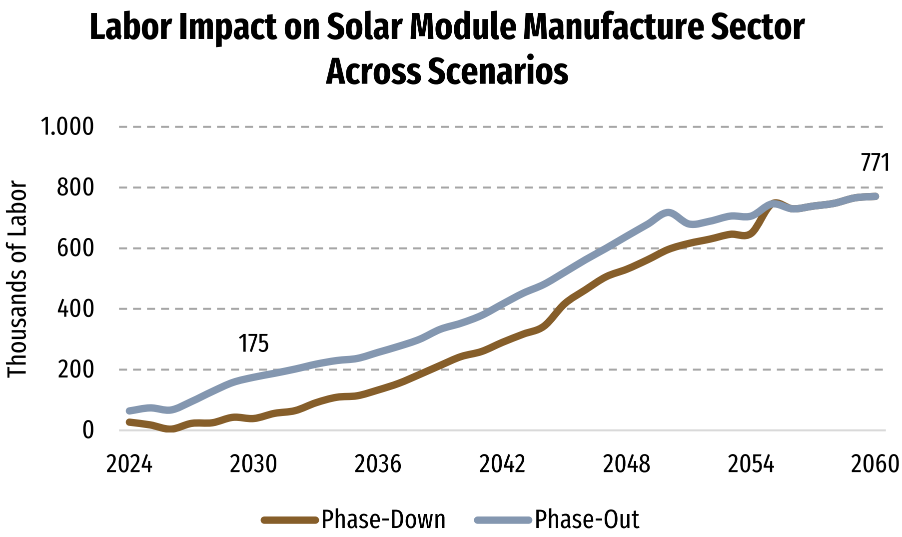
The Phase-Down scenario demonstrates a more gradual increase in employment. Starting with approximately 20,000 workers in 2024, it exhibits slower initial growth until 2042. The employment growth rate then accelerates, eventually converging with the Phase-Out scenario around 2054, and achieving comparable employment levels by 2060.

In comparison with previous analyses of coal-fired power plants and mining sectors, the solar PV sector demonstrates potential to generate substantially more employment opportunities than those displaced from traditional energy sectors (coal). While coal-related employment declines in transition scenarios, the solar PV sector is projected to create approximately 882,000 new jobs by 2060, indicating a positive net employment impact during the energy transition period.

4.3.2 Employment Impact on Solar Module Manufacture Sector

The graph illustrates employment projections in the solar module manufacturing sector under two transition scenarios through 2060.

Figure 26 Labor Impact on Solar Module Manufacture Sector



Source: Analysis of CORE Indonesia (2025)

In the Phase-Out scenario, workforce growth demonstrates a more aggressive trend, starting from approximately 50,000 workers in 2024 and reaching 175,000 workers by 2030. Employment continues to increase steadily, ultimately peaking at around 700,000 workers in 2048 and concluding at 771,000 workers in 2060.

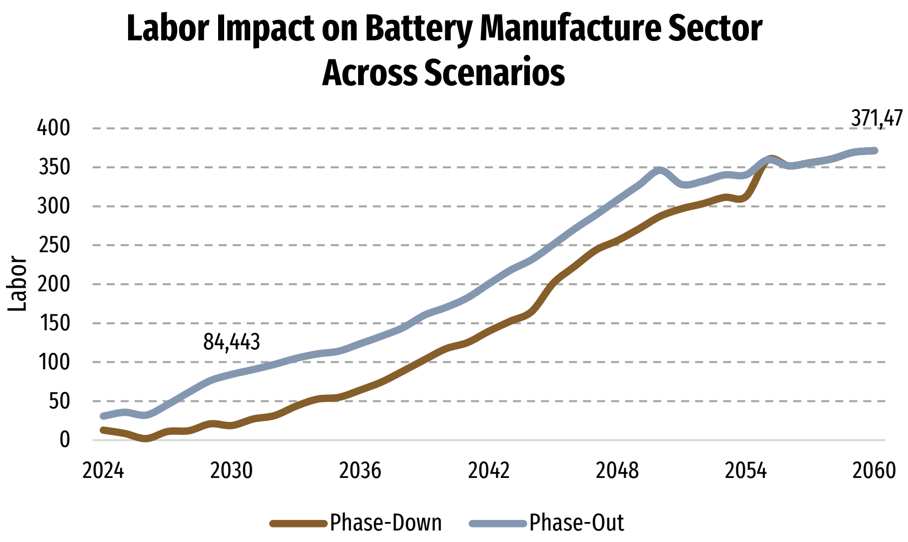
The Phase-Down scenario exhibits a more moderate progression. Beginning with approximately 30,000 workers in 2024, it displays slower growth until 2042. Subsequently, the employment growth rate accelerates significantly, ultimately approaching nearly identical levels to the Phase-Out scenario by 2060.

These projections underscore the substantial job creation potential within the solar module manufacturing industry as part of the energy transition. The sector's growth can provide alternative employment opportunities for workers displaced from conventional energy industries, presenting enhanced long-term employment prospects.

4.3.3 Employment Impact on Battery Manufacture Sector

The graph illustrates employment projections in the battery manufacturing sector across two transition scenarios through 2060.

Figure 27 Labor Impact on Battery Manufacture Sector



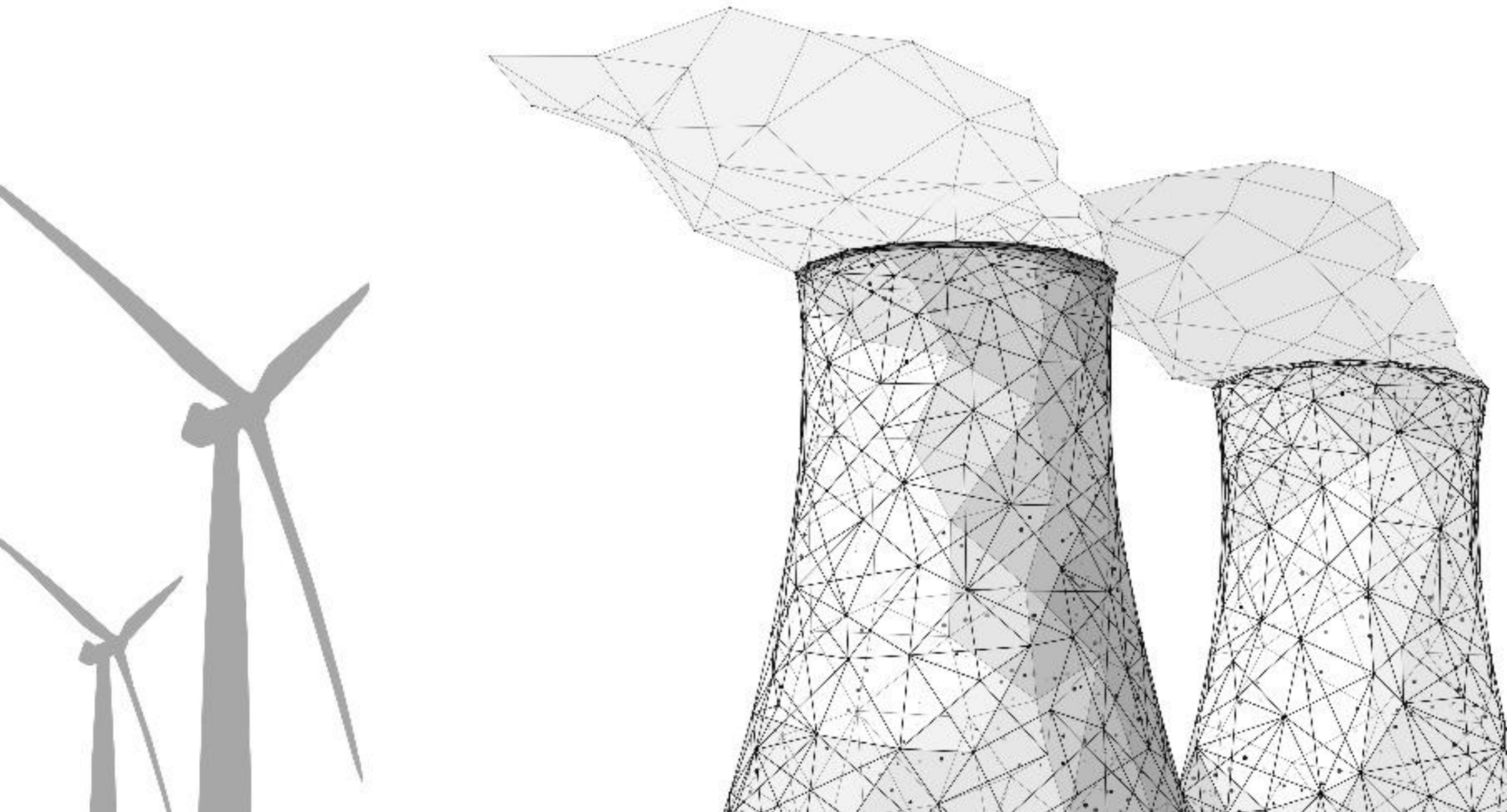
Source: Analysis of CORE Indonesia (2025)

In the Phase-Out scenario, employment growth accelerates more rapidly, starting from approximately 30 workers in 2024 and reaching 84 workers by 2030. Growth continues significantly, reaching approximately 350 workers by 2048, and ultimately achieving 371 workers by 2060. The Phase-Down scenario demonstrates a more gradual increase. Beginning with approximately 10 workers in 2024, growth remains relatively slow until 2036. Subsequently, the employment growth rate accelerates, eventually reaching levels comparable to the Phase-Out scenario by 2060.

These projections indicate job creation potential in the battery manufacturing industry as a support sector for solar energy development, albeit on a smaller scale compared to solar panel manufacturing. This sector's growth can provide new employment opportunities within the renewable energy supply chain

CHAPTER V

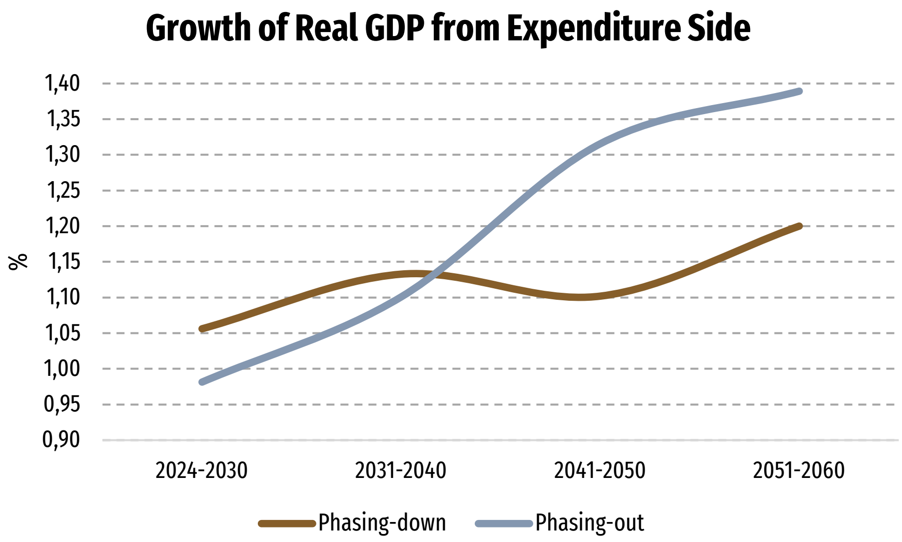
MACROECONOMIC IMPACTS OF EARLY COAL POWER PLANT RETIREMENT IN INDONESIA



5.1 Impact on Economic Growth (Real GDP)

The GDP growth in the phasing-down scenario demonstrates a relatively stable pattern with a positive trend: 1.06% (2024-2030), increasing to 1.13% (2031-2040), slightly declining to 1.10% (2041-2050), and then rising again to 1.20% (2051-2060). This pattern reflects a gradual transition process with minimal economic disruption. The initial growth phase (1.06%) indicates that the gradual reduction of coal-fired power plants provides space for the economy to adapt. The increased growth in the second period (1.13%) is driven by investments in renewable energy technologies and supporting infrastructure. The subsequent decrease in the third period (1.10%) reflects a consolidation phase where the economy adjusts to structural changes. The increase in the final period (1.20%) indicates the realization of productivity gains from a cleaner and more efficient energy system.

Figure 28 Impact on Economic Growth



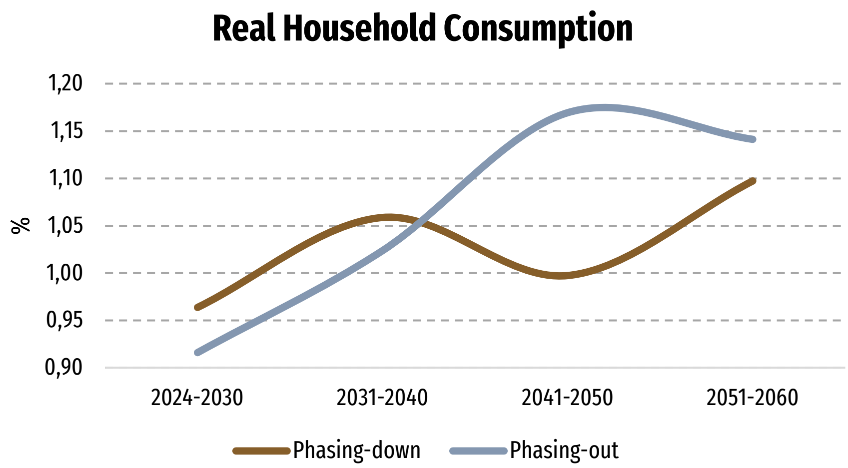
Source: Analysis of CORE Indonesia (2025)

The GDP growth in the phasing-out scenario shows a more dynamic pattern: 0.98% (2024-2030), 1.10% (2031-2040), 1.32% (2041-2050), and 1.39% (2051-2060). The lower initial growth (0.98%) indicates higher short-term adjustment costs due to more rapid termination of coal power. However, the higher long-term growth 1.39% in (2051-2060) compared to 1.20% in the phasing-down scenario) demonstrates greater structural benefits from a faster energy transition.

5.2 Impact on Household Consumption

Household consumption growth in the phasing-down scenario exhibits a stable increasing pattern: 0.96% (2024-2030), 1.06% (2031-2040), 1.00% (2041-2050), and 1.10% (2051-2060). This indicates a gradual improvement in household welfare. In the initial period, consumption growth (0.96%) is slightly lower than GDP growth (1.06%), reflecting a reallocation of resources from consumption to investment to support the energy transition. The fluctuation pattern of consumption that follows GDP trends demonstrates that the benefits of economic growth are transmitted to households, albeit with some lag. Household consumption growth in the phasing-out scenario shows a more progressive increase: 0.92% (2024-2030), 1.02% (2031-2040), 1.17% (2041-2050), and 1.14% (2051-2060). Lower initial consumption (0.92% compared to 0.96% in phasing-down) reflects higher short-term adjustment costs for households.

Figure 29 Impact on Household Consumption



Source: Analysis of CORE Indonesia (2025)

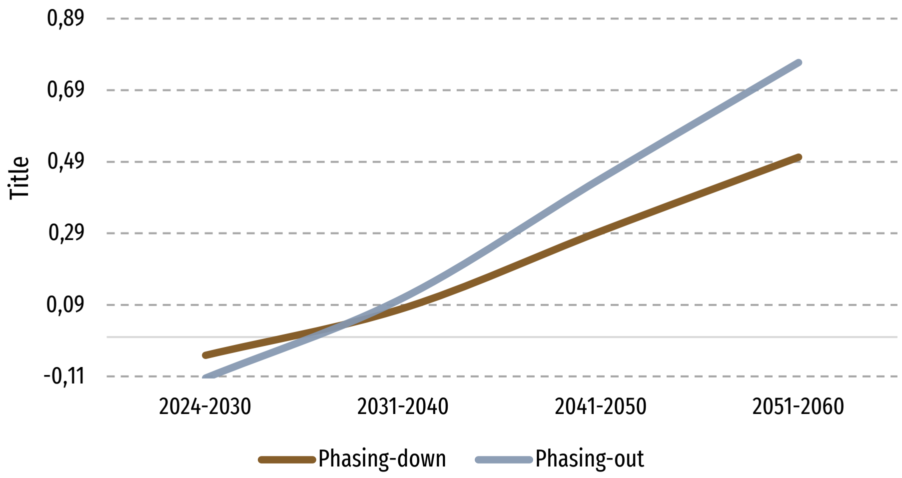
However, higher long-term consumption (1.14% compared to 1.10% in phasing-down) indicates that the benefits of a faster transition are eventually transmitted to household welfare. This pattern also shows that in the phasing-out scenario, household consumption tends to "catch up" with GDP growth in later stages, reflecting a more equitable distribution of growth benefits in the long run.

5.3 Impact on Consumer Prices

The pattern of changes in the consumer price index in the phasing-down scenario shows mild deflation in the initial period (-0.05%), followed by gradually increasing inflation: 0.08% (2031-2040), 0.30% (2041-2050), and 0.50% (2051-2060). Early deflation reflects the impact of increasing energy efficiency and declining energy costs as the energy transition begins. Gradually increasing inflation in subsequent periods reflects aggregate demand pressure as the economy grows, as well as potential structural adjustment costs in the long term.

The price change pattern in the phasing-out scenario is similar but with slightly different intensities: larger initial deflation (-0.11%), followed by more rapidly increasing inflation: 0.11% (2031-2040), 0.44% (2041-2050), and 0.77% (2051-2060). Greater initial deflation may reflect the stronger disinflationary impact of decreased aggregate demand due to short-term economic disruptions. However, higher long-term inflation (0.77% vs 0.50%) is consistent with stronger economic growth and greater demand pressure in this scenario.

Figure 30 Impact on Consumer Price Index



Source: Analysis of CORE Indonesia (2025)

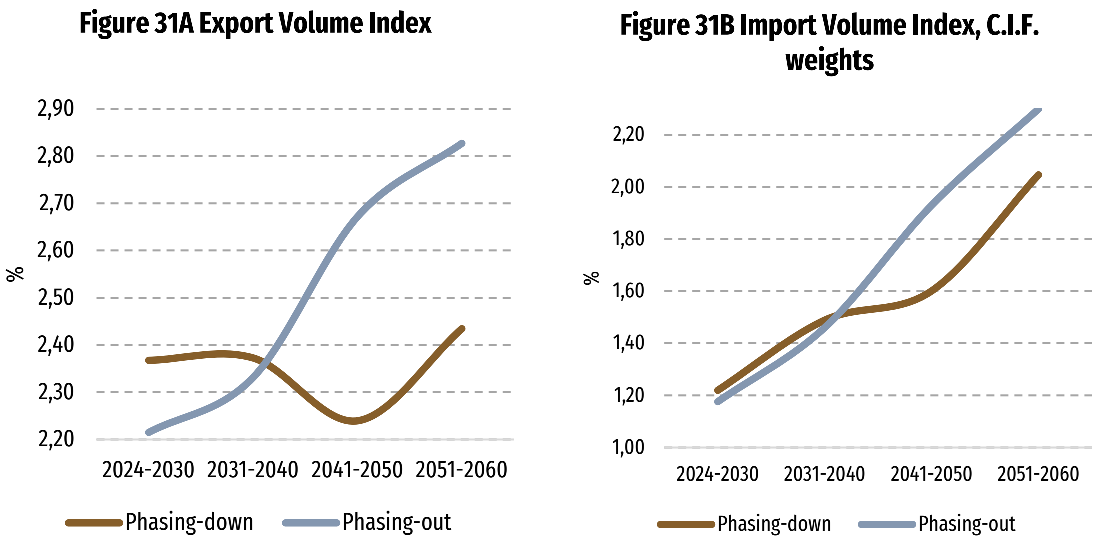
5.4 Impact on International Trade

Import growth in the phasing-down scenario increases consistently: 1.22% (2024-2030), 1.49% (2031-2040), 1.60% (2041-2050), and 2.05% (2051-2060). This persistent increase reflects several factors such as the need to import renewable energy technologies and their components, increased aggregate demand as the economy grows, and possible structural shifts toward more import-dependent sectors.

Import growth consistently exceeding GDP growth indicates an increasing import intensity in the economy, which could pose challenges for the balance of payments if not offset by adequate export growth. The import growth pattern in the phasing-out scenario also increases consistently: 1.18% (2024-2030), 1.46% (2031-2040), 1.93% (2041-2050), and 2.30% (2051-2060). Initial import growth is slightly lower compared to the phasing-down scenario (1.18% vs 1.22%), possibly reflecting the impact of initial economic contraction on import demand. However, in subsequent periods, import growth in the phasing-out scenario exceeds the phasing-down scenario, consistent with higher GDP growth and faster economic transformation toward more technology-intensive and clean energy sectors.

Regarding exports, growth in the phasing-down scenario shows a fairly stable pattern: 2.37% (2024-2030), 2.37% (2031-2040), slightly declining to 2.24% (2041-2050), and then rising again to 2.43% (2051-2060). Export growth consistently exceeding GDP growth indicates increased export orientation and international competitiveness. The slight decrease in the third period (2041-2050) reflects an adjustment phase in the export structure as the domestic production base changes due to the energy transition.

Figure 31 Impact on International Trade



Source: Analysis of CORE Indonesia (2025)

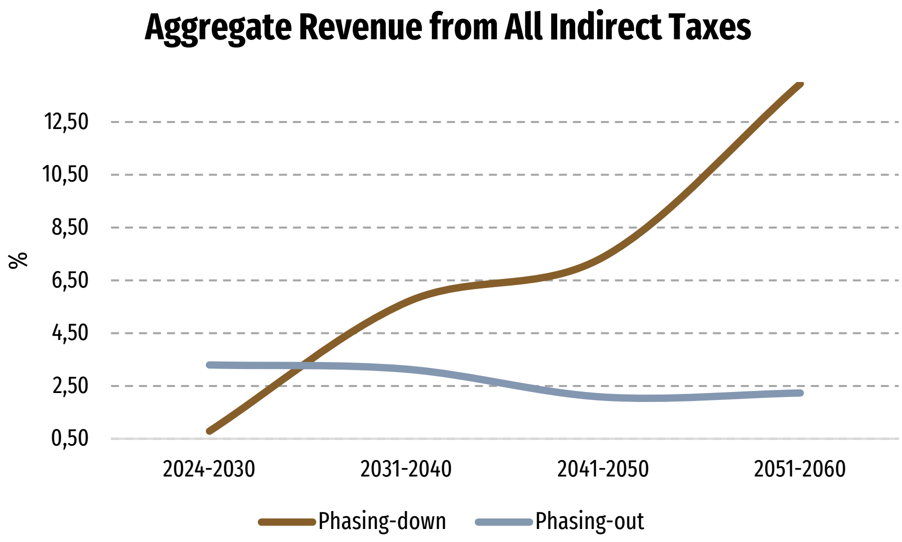
Export growth in the phasing-out scenario shows a more dynamic pattern: 2.21% (2024-2030), 2.33% (2031-2040), increasing to 2.67% (2041-2050), and 2.83% (2051-2060). Lower initial export growth compared to the phasing-down scenario (2.21% vs 2.37%) reflects the initial impact of production disruptions due to faster coal power plant closures.

However, significantly higher long-term export growth (2.83% vs 2.43%) suggests that a faster transition to clean energy can enhance international competitiveness in the long run, possibly through mechanisms such as higher energy efficiency reducing production costs, reduced carbon intensity of production improving access to increasingly environmentally conscious markets, and faster structural transformation driving specialization in high value-added export industries.

5.5 Impact on Indirect Tax Revenue

Indirect tax revenue growth in the phasing-down scenario shows a dramatic increase: 0.79% (2024-2030), 5.67% (2031-2040), 7.38% (2041-2050), and 13.95% (2051-2060). This exponential increase pattern reflects several potential factors, such as the expansion of the tax base along with the structural transformation of the economy. The very high increase in tax revenue in the final period (13.95%) indicates a fundamental change in the fiscal structure, which can provide wider fiscal space for supportive public policies.

Figure 32 Impact on Indirect Tax Revenue



Source: Analysis of CORE Indonesia (2025)

Indirect tax revenue growth in the phasing-out scenario shows a very different pattern: relatively high initially at 3.30% (2024-2030), stable at 3.14% (2031-2040), declining to 2.08% (2041-2050), and slightly increasing to 2.23% (2051-2060). Higher initial growth (3.30% vs 0.79% in phasing-down) reflects the potential for rapid changes in the tax structure to compensate for lost revenue from the coal sector.

5.6 Impact on Real Wages

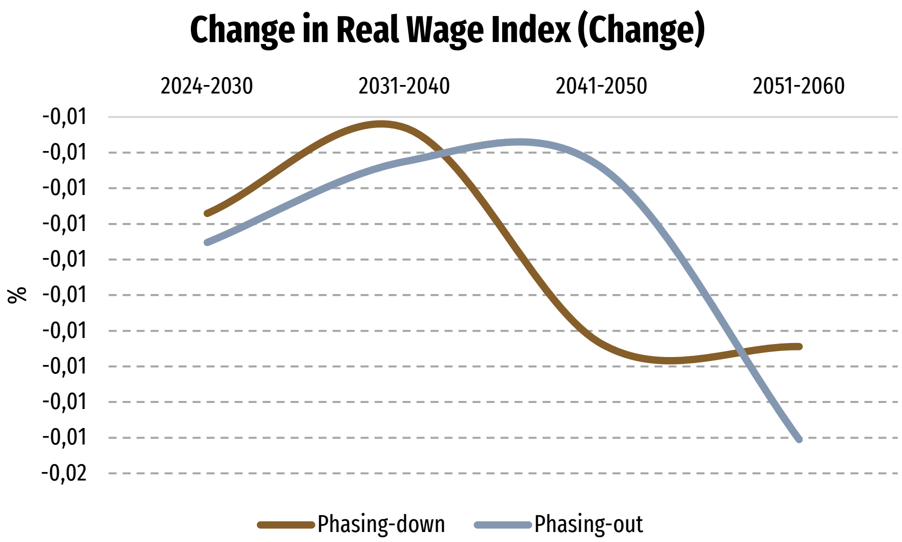
Changes in the real wage index in the phasing-down scenario are consistently negative across all periods: -0.0135% (2024-2030), -0.0131% (2031-2040), -0.0143% (2041-2050), and -0.0143% (2051-2060). Although the magnitude of the decrease is small, the persistence of the decline across all periods indicates structural challenges in the labor market. This small but persistent decline in real wages reflects several factors:

- Skills mismatch between workers displaced from the coal sector and the needs of new sectors;
- Shift from high-wage sectors (such as mining) to lower-wage sectors;
- Changes in the composition of labor demand toward different skills.

Changes in real wages in the phasing-out scenario are also consistently negative and similar in magnitude: -0.0137% (2024-2030), -0.0133% (2031-2040), -0.0133% (2041-2050), and slightly increasing to -0.0148% (2051-2060).

The small differences between the two scenarios suggest that the impact on real wages is relatively resistant to different transition approaches, indicating that labor market challenges are inherent in the energy transition process itself.

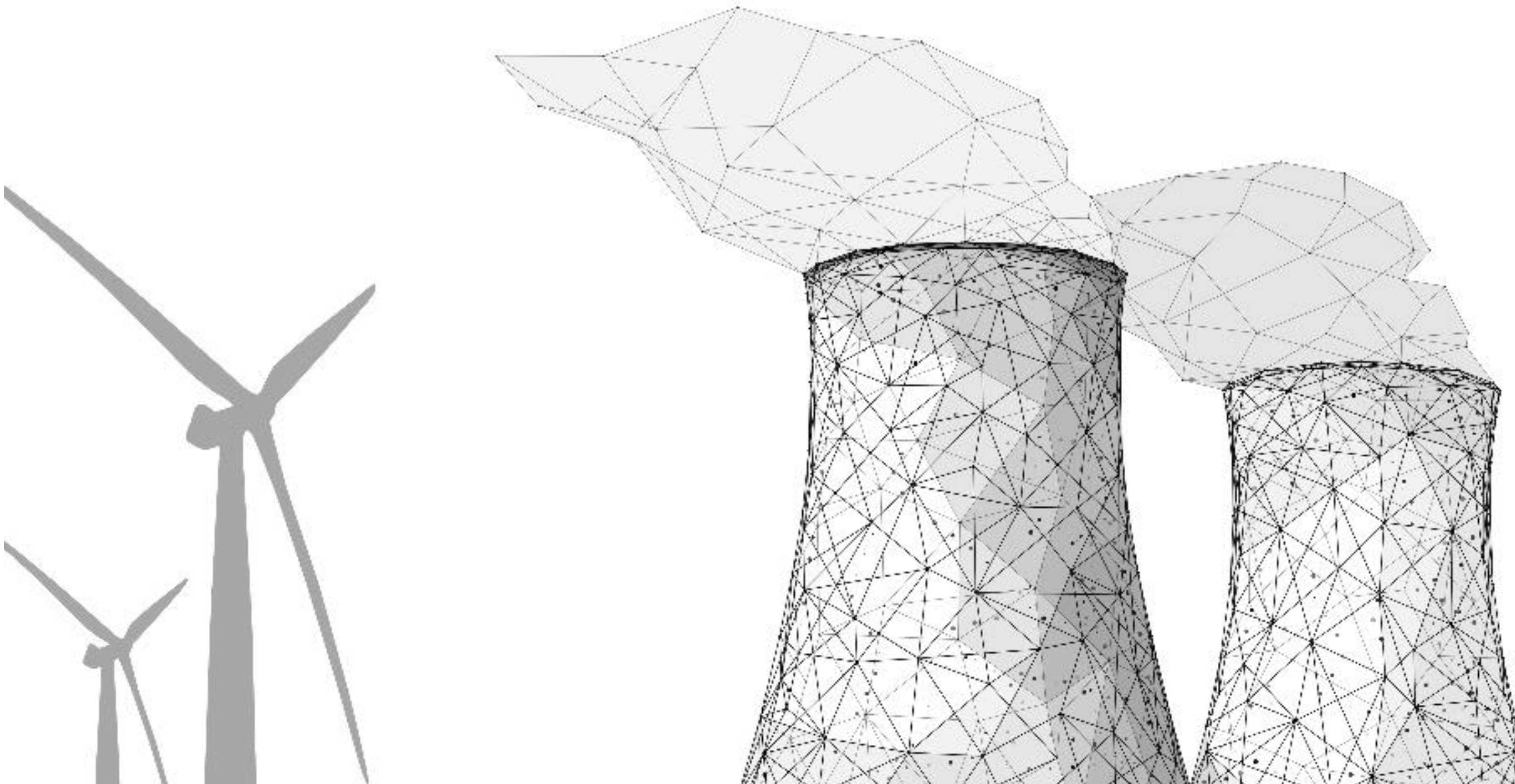
Figure 33 Impact on Real Wage



Source: Analysis of CORE Indonesia (2025)

The slight increase in real wage decline in the final period in the phasing-out scenario (-0.0148% vs -0.0143%) may reflect the impact of more intensive structural transformation in the economy. Although the impact on real wages is relatively small compared to the overall macroeconomic benefits, the persistence of negative impacts indicates potential areas for policy intervention and investment in human capital.

CHAPTER VI
MITIGATION STRATEGY FOR ENERGY TRANSITION IN INDONESIA



6.1 Overview of Mitigation Strategy for Energy Transition in Various Countries

6.1.1 Rein-in Strategy

The rein-in strategy represents a top-down regulatory approach where governments implement strict environmental standards, carbon pricing, or operation permit revocations to accelerate coal power plant retirements (Brutschin et al., 2022). This approach typically involves direct intervention through policy mechanisms such as carbon taxes, emissions trading systems, or enhanced environmental regulations that make coal operations economically unfeasible (Nugroho & Chalid, 2024).

One significant advantage of the rein-in strategy is its effectiveness in achieving rapid emissions reductions through clear regulatory frameworks. For instance, in China, the Weiquiao power plant's four units (1,320 MW) were shut down after eight years of operation following a pollution scandal (Brutschin et al., 2022). Similarly, the Netherlands' Maasvlakte plant (603 MW) closed due to inability to meet new efficiency standards (Brutschin et al., 2022).

However, the main drawback of this strategy is its potential to create economic disruption and social resistance, particularly in regions heavily dependent on coal. According to Clark and Zhang (2022), such transitions require proactive fiscal strategies to mitigate socioeconomic impacts, particularly regarding job losses and tax revenue declines.

6.1.2 Buy-out Strategy

The buy-out strategy involves providing financial compensation to coal power plant operators for early retirement of their assets (Srivastav & Zaehringer, 2024). This approach typically includes competitive auctions where operators bid for compensation based on their projected losses from early closure, including lost revenue, decommissioning costs, environmental rehabilitation, and worker severance payments (Nacke, 2020).

The strategy's primary advantage is its market-based approach that helps reduce resistance from stakeholders. Germany's Coal Exit Act (2020) demonstrates successful implementation, allowing voluntary exits between 2020-2026 through compensation auctions, with mandatory closures without compensation after 2027 (Srivastav & Zaehringer, 2024). Chile has also implemented a similar scheme, offering low-interest loans for renewable energy development alongside retirement compensation (Srivastav & Zaehringer, 2024).

The main limitation of the buy-out strategy is its high fiscal cost. According to Nacke et al. (2023), China is estimated to need $2.3 trillion and India $1 trillion for compensation packages. Additionally, determining fair compensation levels can be challenging, and there's a risk of overcompensation if auction mechanisms aren't properly designed (Srivastav & Zaehringer, 2024).

6.1.3 Crowd-out Strategy

The crowd-out strategy leverages market dynamics and competitive forces to phase out coal power by making renewable energy more economically attractive (Nugroho & Chalid, 2024). This approach typically involves fiscal policies such as tax exemptions or subsidies for renewable energy development, making clean energy more cost-competitive compared to coal power plants (Clark & Zhang, 2022).

This strategy's main advantage is its ability to create sustainable market transformation without direct intervention in coal plant operations. It also supports the development of alternative energy sectors and can create new job opportunities. Spain has successfully implemented this approach by promoting renewable energy transitions while providing support for affected mining regions through infrastructure and education programs (Nacke, 2020).

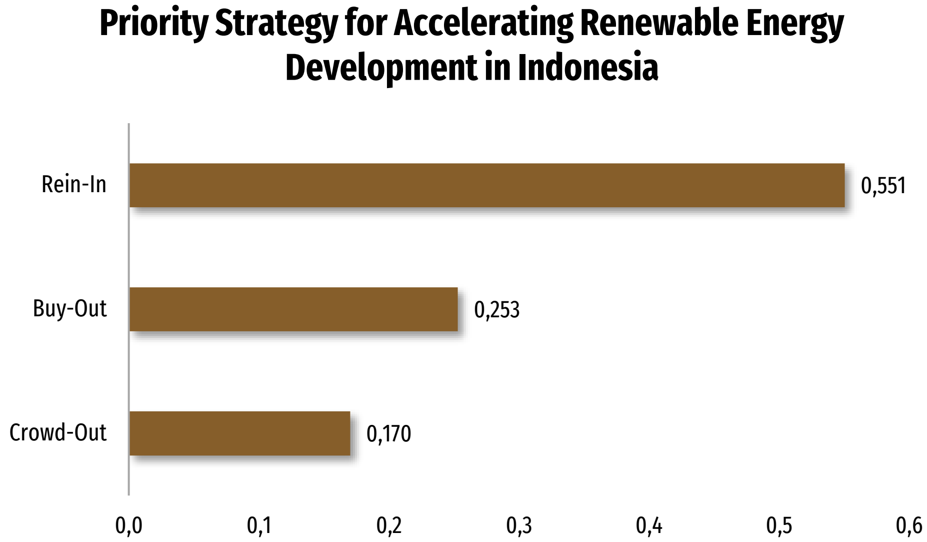
However, the crowd-out strategy generally requires longer implementation timeframes compared to other approaches and may not achieve rapid emissions reductions needed for urgent climate targets (Fofrich et al., 2020). It also requires significant initial investment in renewable energy infrastructure and may face challenges in regions where coal remains artificially competitive due to existing subsidies or market structures (Burke, 2022).

6.2 Expert Choices in Indonesia's Case Study

6.2.1 Expert Choices on Priority Strategy for Renewable Energy Development in Indonesia

Based on the analytical hierarchy process (AHP) assessment shown in the figure below, the Rein-in strategy emerges as the highest priority approach for accelerating renewable energy development in Indonesia, with a weight of 0.551. This is followed by the Buy-out strategy at 0.253 and the Crowd-out strategy at 0.170, indicating a clear preference for regulatory intervention over market-based mechanisms.

Figure 34 Priority Strategy for Accelerating Renewable Energy Development in Indonesia



Source: Analysis of CORE Indonesia (2025)

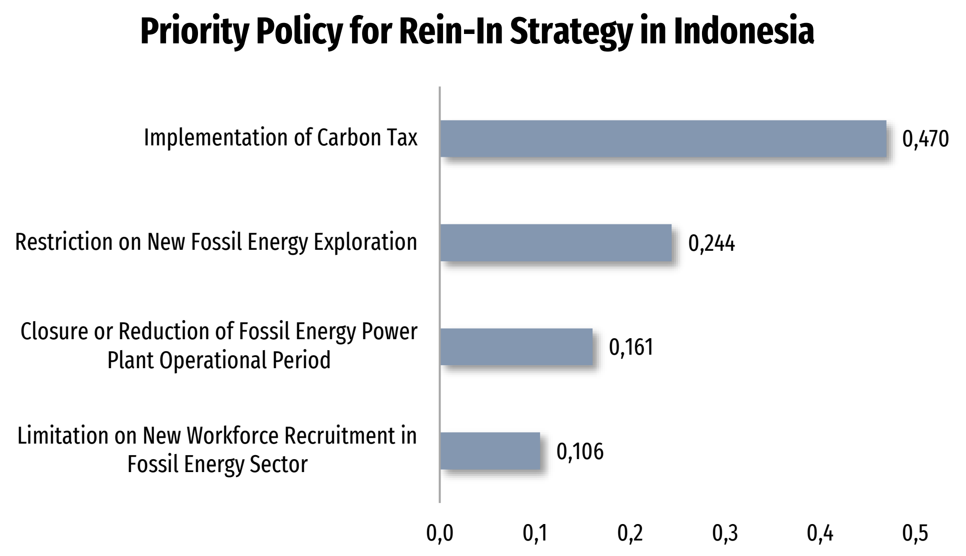
According to Nugroho and Chalid (2024), the Rein-in strategy's dominance is particularly relevant for Indonesia's context, as it involves implementing stricter fiscal policies through carbon taxes and enhanced environmental standards for coal power plants. This approach aligns with evidence from China, where regulatory enforcement led to significant outcomes, such as the closure of the Weiquiao power plant's four units following environmental violations (Brutschin et al., 2022). The effectiveness of this strategy is further supported by Srivastav and Zaehringer (2024), who argue that strong regulatory frameworks are especially crucial in markets where coal lobbies maintain substantial influence.

The lower prioritization of Buy-out (0.253) and Crowd-out (0.170) strategies reflect practical constraints in Indonesia's context. While Buy-out strategies have shown success in countries like Germany through their Coal Exit Act, Nacke et al. (2023) highlight that such approaches require substantial fiscal resources - with estimates reaching trillions of dollars for large coal-dependent economies. Similarly, the Crowd-out strategy's lower priority aligns with Clark and Zhang's (2022) findings that market-based transitions, while potentially more politically palatable, may not deliver the rapid emissions reductions needed to meet urgent climate targets, particularly in developing economies where renewable energy infrastructure requires significant initial investment.

6.2.2 Expert Choices on Priority Policy for Rein-in Strategy in Indonesia

Based on the AHP assessment of policy priorities for the Rein-in strategy in Indonesia, the implementation of carbon tax emerges as the most crucial policy instrument with a weight of 0.470. This is followed by restrictions on new fossil energy exploration (0.244), closure or reduction of fossil energy power plant operational periods (0.161), and limitations on new workforce recruitment in the fossil energy sector (0.106).

Figure 35 Priority Policy for Rein-In Strategy in Indonesia



Source: Analysis of CORE Indonesia (2025)

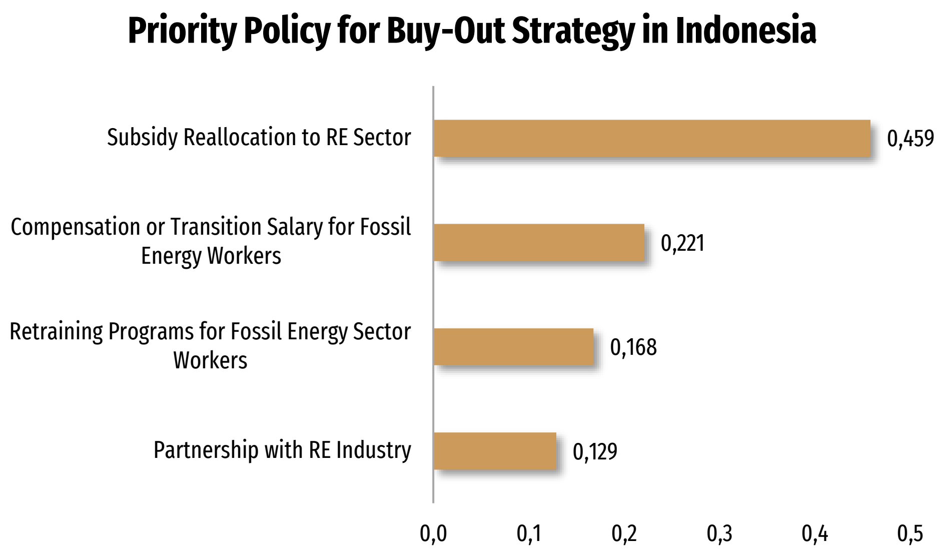
The high priority given to carbon tax implementation aligns with findings from Sumarno and Laan (2021), who demonstrate the effectiveness of coal taxation in reducing carbon emissions while generating significant government revenue. Their analysis of India's experience shows that gradually increasing coal tax from INR 50 to INR 400 per ton generated approximately USD 3.7 billion in 2019, with 30% allocated to renewable energy projects and environmental initiatives. This approach not only internalized environmental costs but also helped prevent an estimated 270,000 premature deaths from air pollution by 2030.

The lower priorities assigned to operational restrictions (0.161) and workforce limitations (0.106) reflect the complex socio-economic considerations involved in energy transition. As highlighted by Clark and Zhang (2022), provinces dependent on coal revenue require diversification of income sources and skill bases to manage tax revenue decline and job losses. This aligns with Nacke et al.'s (2023) findings that successful coal phase-out requires comprehensive compensation mechanisms, with estimates suggesting that large coal-dependent economies need substantial funding - potentially trillions of dollars - to support just transition initiatives, including worker retraining and regional economic diversification programs. The moderate priority given to exploration restrictions (0.244) suggests a balanced approach between environmental goals and economic stability, particularly important in developing economies like Indonesia.

6.2.3 Expert Choices on Priority Policy for Buy-out Strategy in Indonesia

Based on the analytical hierarchy process (AHP) assessment of policy priorities for the Buy-out strategy in Indonesia, subsidy reallocation to the renewable energy sector emerges as the highest priority policy with a weight of 0.459. This is followed by compensation or transition salary for fossil energy workers (0.221), retraining programs for fossil energy sector workers (0.168), and partnership with renewable energy industry (0.129).

Figure 36 Priority Policy for Buy-Out Strategy in Indonesia



Source: Analysis of CORE Indonesia (2025)

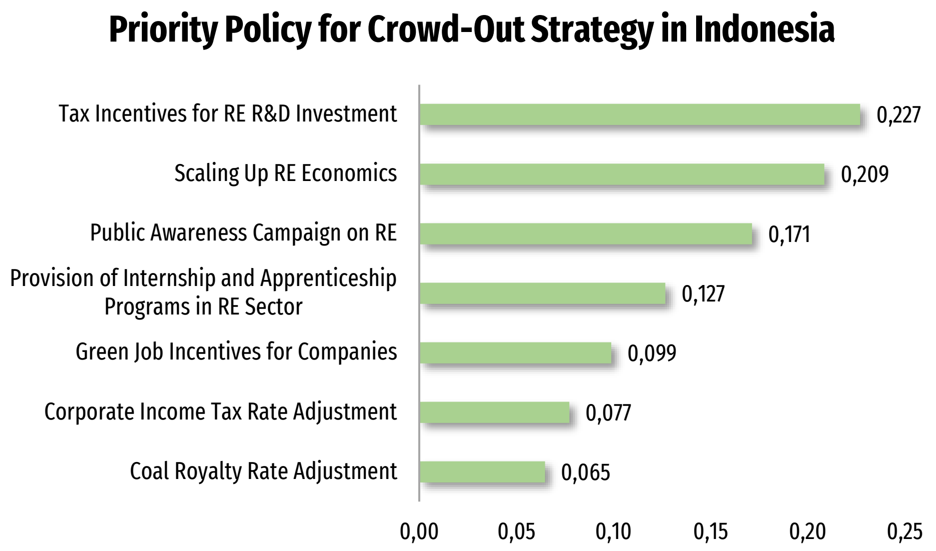
The strong preference for subsidy reallocation aligns with evidence from Germany's experience, where comprehensive financial support mechanisms have proven effective. According to Nacke (2020), the German government allocated substantial funds for infrastructure projects, education, and economic diversification in coal-dependent regions like Lausitz and Rhine. This approach helped create new employment opportunities while reducing regional economic dependence on coal. Similarly, Srivastav and Zaehringer (2024) highlight how Chile's Coal Asset Retirement Scheme successfully combined compensation with low-interest loans for renewable energy development, demonstrating the effectiveness of redirecting financial support toward clean energy initiatives.

The moderate priorities given to worker compensation (0.221) and retraining programs (0.168) reflect the crucial need for just transition measures. This aligns with Clark and Zhang's (2022) findings in China, where the government allocated a Special Industrial Fund of CNY 100 billion (approximately USD 15 billion) for worker relocation, welfare payments, and public sector job creation. A practical example comes from Shanxi province, which secured CNY 3.5 billion in 2022 for worker relocation, retraining, early retirement, and public sector employment creation to offset the impacts of coal capacity control policies. The relatively lower priority for renewable energy industry partnerships (0.129) suggests a focus on immediate socio-economic support measures over longer-term industry restructuring, though both remain essential components of a comprehensive transition strategy.

6.2.4 Expert Choices on Priority Policy for Crowd-out Strategy in Indonesia

Based on the analytical hierarchy process (AHP) assessment of policy priorities for the Crowd-out strategy in Indonesia, tax incentives for renewable energy R&D investment ranks highest with a weight of 0.227, followed by scaling up RE economics (0.209) and public awareness campaign on RE (0.171). Lower priorities include internship and apprenticeship programs (0.127), green job incentives (0.099), corporate income tax rate adjustment (0.077), and coal royalty rate adjustment (0.065).

Figure 37 Priority Policy for Crowd-Out Strategy in Indonesia



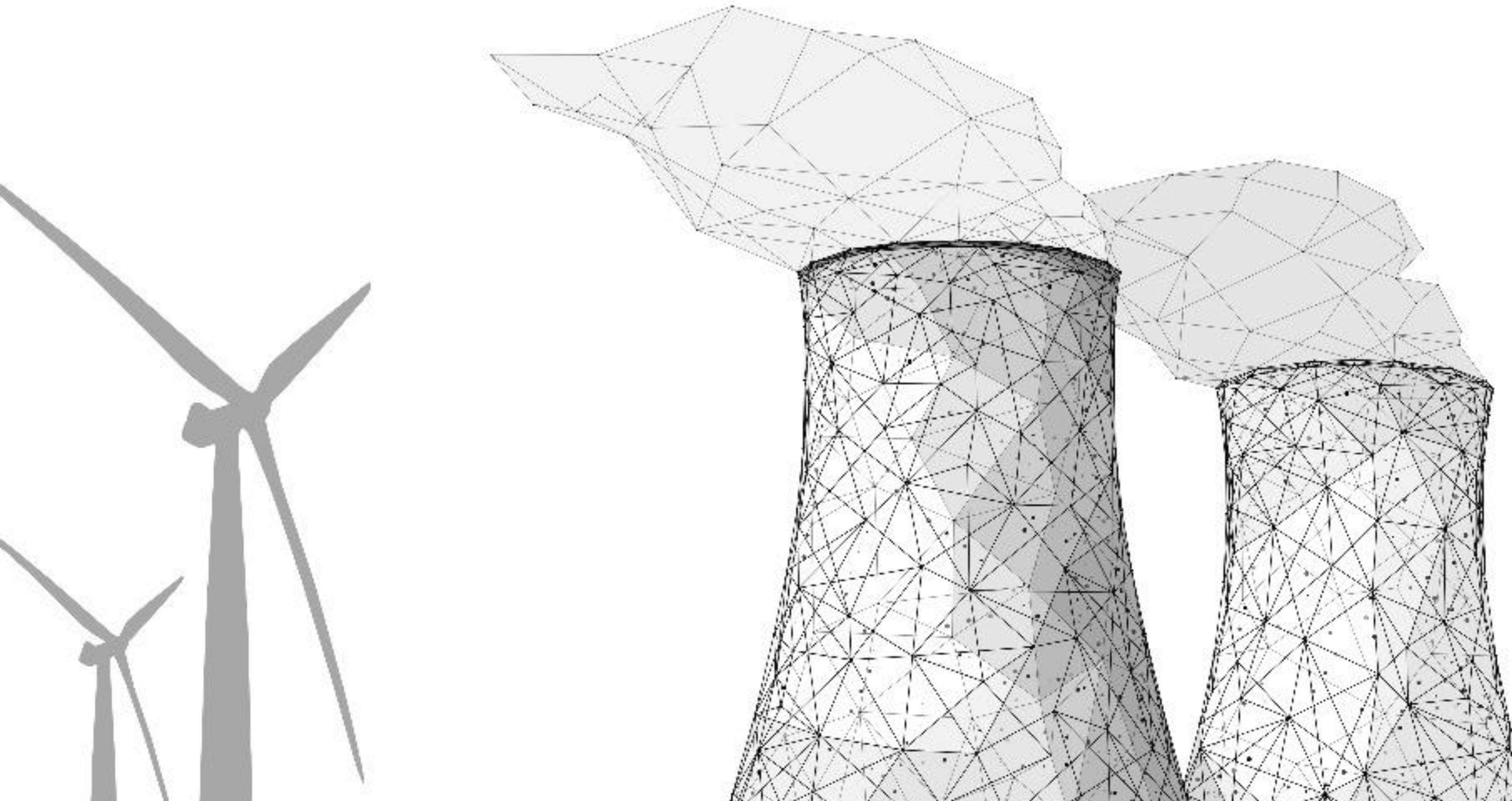
Source: Analysis of CORE Indonesia (2025)

The emphasis on R&D investment incentives (0.227) and scaling up renewable energy economics (0.209) aligns with findings from Burke (2022), who identifies the importance of massive investment in low-carbon energy technologies, particularly solar and wind power generation. This prioritization is supported by evidence from Spain's experience, where Nacke (2020) documents successful promotion of renewable energy transitions through integrated infrastructure and education programs in former mining regions. The significant weight given to public awareness campaigns (0.171) further reflects the importance of building social acceptance and understanding of renewable energy development.

The relatively lower priorities assigned to fiscal adjustments (corporate tax and royalty rates at 0.077 and 0.065 respectively) reflect the findings from Sumarno and Laan (2021), who suggest that while tax measures can support transition, they should not be the primary policy focus. The moderate emphasis on workforce development through internships (0.127) and green job incentives (0.099) aligns with Clark and Zhang's (2022) findings that skill development and job creation in new sectors are crucial for managing the socioeconomic impacts of energy transition, though these may be more effective when implemented alongside stronger market-based incentives focused on R&D and economic scaling.

CHAPTER VII

CONCLUSION AND POLICY RECOMMENDATIONS



7.1 Conclusion

The early retirement of coal-fired power plants (CFPPs) in Indonesia represents a fundamental economic and energy transition with complex, multidimensional impacts across GDP, fiscal, and employment sectors. This study's comprehensive analysis reveals distinct impact patterns under three scenarios (Business as Usual, Phase-Down, and Phase-Out), offering valuable insights for policy formulation.

The GDP analysis demonstrates that while CFPP retirement would gradually reduce the coal sector's economic contribution (from 1.9% in BaU to 0.2% in Phase-Out by 2041-2050), this decline would be more than offset by growth in renewable energy sectors. Solar PV development, including module manufacturing and battery production, shows potential to contribute up to consecutively 709.2 trillion of Rupiah and 659.8 trillion of Rupiah in the Phase-Out and Phase-Down scenario, exceeding the lost coal sector contribution 561.5 trillion of Rupiah in 2051-2060 average per year. This indicates that with proper policy support, Indonesia can achieve economic growth while transitioning to cleaner energy sources.

From a fiscal perspective, the transition presents a significant structural shift in government revenue streams. Under the Phase-Down and Phase-Out scenarios, traditional revenue from coal-related activities (including VAT, corporate income tax, and royalties) would decline substantially. However, the analysis reveals emerging fiscal opportunities from the renewable energy ecosystem. The solar PV sector and its manufacturing supply chain could generate substantial tax revenue, potentially exceeding Rp 491 trillion per year by 2051-2060 in the Phase-Out scenario compared to Rp 473 trillion in Phase Down scenario. Additionally, transitioning from direct electricity subsidies to installation subsidies for solar infrastructure presents a more fiscally sustainable approach in the long term. In the Phase-out scenario, electricity subsidies decrease consistently from 46 trillion Rupiah (2024-2030) to zero by 2051-2060, demonstrating the efficiency of this approach. This scenario assumes that decreased production from coal-fired power plants will be replaced by solar PV, whose costs (LCOE) continue to decline due to increasing efficiency in production and construction, further enhancing the fiscal benefits of the transition.

The employment impact analysis yields particularly promising results, showing that job losses in coal mining and power generation would be significantly outweighed by new employment opportunities in renewable energy sectors. While the coal sector (coal mining and CFPP) will support approximately 77 thousand of jobs in BAU scenario, the solar PV ecosystem (including installation, operation, and manufacturing) could potentially create over 1,25 million of jobs by 2060 in the Phase-Out scenario. This sixteen-fold increase in clean energy employment demonstrates the transition's potential to not only maintain but substantially expand Indonesia's energy workforce.

Macroeconomic modeling further confirms that early CFPP retirement, particularly in the Phase-Out scenario, would deliver positive long-term economic outcomes. While the initial transition period (2024-2030) may experience slightly lower GDP growth compared to BaU, this pattern reverses in subsequent decades, with the Phase-Out scenario achieving the highest long-term growth rate of 1.39% by 2051-2060, with assumption that almost all components are produced domestically. Household consumption, exports, and tax revenue similarly show improved long-term performance under accelerated transition scenarios, though careful management of real wage impacts remains necessary.

The Analytical Hierarchy Process for mitigation strategies identified a clear preference hierarchy among experts, prioritizing the Rein-in strategy (0.551) over Buy-out (0.253) and Crowd-out (0.170) approaches. Among specific policy instruments, carbon taxation (0.470) emerged as the most important tool within the Rein-in framework, while subsidy reallocation to the renewable energy sector (0.459) was prioritized under the Buy-out approach. As for Crowd-out, the incentives for RE R&D is the highest priority opinion strategies from the expert.

In conclusion, Indonesia's transition away from coal dependency represents not merely an environmental imperative but a significant economic opportunity. The analysis demonstrates that with appropriate planning and policy implementation, early CFPP retirement coupled with strategic renewable energy development can deliver net positive impacts across GDP, fiscal, and employment dimensions. However, this transition must be managed carefully to address potential short-term disruptions and ensure equitable distribution of costs and benefits across sectors and regions.

7.2 Policy Recommendations

The policy recommendations outlined by CORE Indonesia present a comprehensive framework for Indonesia's transition away from coal-fired power plants (PLTU) toward renewable energy. These strategies address the economic, fiscal, and social challenges identified in their research on early coal power plant retirement impacts. The recommendations balance environmental objectives with practical considerations for maintaining economic stability while progressively transforming the energy sector.

Strong synchronization between coal power plant phase-out and renewable energy development stands as a fundamental requirement for a successful transition. This policy recognizes that poorly coordinated closures of coal facilities without adequate renewable replacement capacity could create energy security vulnerabilities. The document emphasizes the need for careful sequencing to maintain grid stability while steadily reducing coal dependence—a particularly important consideration given Indonesia's archipelagic geography and growing energy demands.

Redirecting existing subsidies from fossil fuel sectors to renewable energy development represents a fiscally responsible approach to accelerating the transition. By shifting financial support toward solar power (PLTS) implementation with a focus on reducing installation costs, the government can address one of the primary barriers to renewable adoption without necessarily increasing overall subsidy expenditures. This approach aligns with the document's findings regarding potential cost savings from reduced electricity subsidies as renewables become more competitive.

Tax incentives for renewable energy research and development create a foundation for long-term technological self-sufficiency. This forward-looking policy aims to stimulate private investment in strategic renewable sectors including solar panel manufacturing and battery storage systems. The document's economic analysis demonstrates significantly higher GDP contributions when renewable components are manufactured domestically rather than imported, underscoring the importance of developing local technological capabilities.

Supporting local renewable energy manufacturing through industrial scaling policies addresses both economic growth and employment objectives. By strengthening domestic supply chains and reducing import dependence through targeted workforce training and production capacity enhancement, Indonesia can create substantial new employment opportunities in the renewable sector. The research indicates that solar PV and manufacturing sectors could potentially generate over 800,000 jobs by 2060, more than offsetting losses in coal-related employment.

Implementing a progressive carbon tax mechanism provides a market-based approach to accelerating the energy transition. By incorporating environmental costs into coal power generation through adjustments to corporate taxation and coal royalties, this policy creates economic incentives for efficiency improvements while encouraging shifts toward cleaner alternatives. This aligns with the document's finding that regulatory approaches (the "rein-in strategy") received the highest priority among consulted experts.

Limiting new coal exploration permits and gradually reducing production quotas establishes a clear signal for long-term market planning. This supply-side policy complements demand-reduction measures by constraining new coal resource development to align with Indonesia's climate commitments, including the Paris Agreement target of net-zero emissions by 2060 or sooner. The phased approach allows for gradual adjustment rather than sudden disruption.

Comprehensive worker compensation and retraining programs form an essential component of ensuring a just transition. With approximately 250,000 workers in the coal supply chain potentially affected by the phase-out, dedicated policies for employment transition are critical. This recommendation acknowledges the regional concentration of mining activities and the need for targeted support in coal-dependent communities, particularly in provinces like East Kalimantan where the industry represents a significant portion of the regional economy. []

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APPENDIX

Appendix 1 GDP Analysis Formula

GVA in CFPP Sector

$$GVA_{CFPP} = \sum [Y_{CFPPi} - I_{CFPPi}]$$
$$GVA_{CFPP} = \sum [Q_{CFPPi} \times (T_{CFPPi} + S_{CFPPi} - IC_{CFPPi})] \quad (1)$$

With:

Y_{CFPPi}	=	Output value of CFPP in the year i (Rp);
I_{CFPPi}	=	Intermediary consumption of CFPP in the year i (Rp);
Q_{CFPPi}	=	Total electricity production of CFPP in the year i (TWh);
T_{CFPPi}	=	Electricity tariff of CFPP in the year i (Rp Billion per TWh);
S_{CFPPi}	=	Electricity subsidy in the year i (Rp Billion per TWh);
IC_{CFPPi}	=	Intermediary consumption cost of CFPP in the year i (Rp Billion per TWh).

GVA in Coal Mining Sector

$$GVA_{Coal} = \sum [Y_{Coali} - I_{Coali}]$$
$$GVA_{Coal} = \sum \left[Q_{Coali} \times \left((P_{Coali} \times ER) - IC_{Coali}\right)\right] \quad (2)$$

With:

Y_{Coali}	=	Output value of coal mining in the year i (Rp);
I_{Coali}	=	Intermediary consumption of coal mining in the year i (Rp);
Q_{Coali}	=	Total coal consumption of on-grid CFPP in the year i (Mt);
P_{Coali}	=	DMO price of coal in the year i (USD per t);
ER	=	Middle exchange rate in the year i (USD per IDR);
IC_{Coali}	=	Intermediary consumption cost of coal mining in the year i (Rp Billion per Mt).

GVA in Solar PV Sector

$$GVA_{SPV} = \sum [Y_{SPVi} - I_{SPVi}]$$
$$GVA_{SPV} = \sum \left[Q_{SPVi} \times \left((T_{SPVi} \times ER) + S_{SPVi} - IC_{SPVi}\right)\right] \quad (3)$$

With:

Y_{SPVi}	=	Output value of solar PV in the year i (Rp);
I_{SPVi}	=	Intermediary consumption of solar PV in the year i (Rp);
Q_{SPVi}	=	Total electricity production of solar PV in the year i (TWh);
T_{SPVi}	=	Electricity tariff of solar PV in the year i (USD per kWh);

ER = Middle exchange rate in the year i (USD per IDR);
S_{SPVi} = Installation cost subsidy in the year i (Rp Billion per TWh);
IC_{SPVi} = Intermediary consumption cost of solar PV in the year i (Rp Billion per TWh).

GVA in Solar Module Industry Sector

$$GVA_{Module} = \sum [Y_{Modulei} - I_{Modulei}]$$
$$GVA_{Module} = \sum [Q_{Modulei} \times ((P_{Modulei} \times ER) - IC_{Modulei})] \quad (4)$$

With:

$Y_{Modulei}$ = Output value of solar module in the year i (Rp);
$I_{Modulei}$ = Intermediary consumption of solar module in the year i (Rp);
$Q_{Modulei}$ = Total production of solar module in the year i (Unit);
$P_{Modulei}$ = Selling price of solar module in the year i (CNY per Unit);
ER = Middle exchange rate in the year i (CNY per IDR);
$IC_{Modulei}$ = Intermediary consumption cost of solar module in the year i (Rp per Unit).

GVA in Battery Industry Sector

$$GVA_{Battery} = \sum [Y_{Batteryi} - I_{Batteryi}]$$
$$GVA_{Battery} = \sum \left[Q_{Batteryi} \times \left(\left(P_{Batteryi} \times ER\right) - IC_{Batteryi}\right)\right] \quad (5)$$

With:

$Y_{Batteryi}$ = Output value of battery in the year i (Rp);
$I_{Batteryi}$ = Intermediary consumption of battery in the year i (Rp);
$Q_{Batteryi}$ = Total production of battery in the year i (Unit);
$P_{Batteryi}$ = Selling price of battery in the year i (KRW per Unit);
ER = Middle exchange rate in the year i (KRW per IDR);
$IC_{Batteryi}$ = Intermediary consumption cost of battery in the year i (Rp per Unit).

Appendix 2 Fiscal Analysis Formula

1. Value Added Tax (VAT)

Coal Mining Sector

$$Input\ VAT = Q\ coal\ [(COGS\ coal + Opex\ coal]x\ pVAT \quad (6)$$
$$Output\ VAT = Q\ coal\ x\ P\ coal\ x\ pVAT \quad (7)$$
$$Mining's\ VAT = Output\ VAT\ - Input\ VAT \quad (8)$$

With:

Q coal = Total coal consumption from CFPP (Mt);
COGS coal = Company's cost of goods sales (Rp Billion per Mt);
Opex coal = Company's operating expenses (Rp Billion per Mt);
$pVAT$ = Input tax rate (%);
P coal = Reference price of coal (Rp Billion per Mt);
$pVAT$ = Output tax rate (%).

CFPP Sector

CFPP's VAT

$$CFPP's\ VAT = Q\ CFPP\ x\ P\ CFPP\ x\ pVAT \tag{9}$$

With:
Q CFPP = Total sales of electricity (TWh);
P CFPP = Electricity tariff (Rp per TWh);
$pVAT$ = T rate (%).

CFPP's CIT

$$CFPP's\ CIT = \big[[(P\ CFPP\ + S\ CFPP)\ x\ Q\ CFPP] - (C\ CFPP\ X\ Q\ CFPP)\big]\ x\ pCIT \tag{10}$$

With:
P CFPP = Electricity tariff (Rp per TWh);
Q CFPP = Total sales of electricity (TWh);
S CFPP = Subsidy of electricity (include compensation) (Rp Billion per TWh);
C CFPP = PLN's cost of goods sales (Rp Billion per TWh);
$pCIT$ = Corporate Income Tax rate (%).

2. **Personal Income Tax**

Coal Mining Sector

$$Personal\ Income_{nett} = Ave\ Wage\ - Ave\ Health\ IC \tag{11}$$
$$T_{taxable} = Personal\ Income_{nett} - T_{deduction} \tag{12}$$
$$Tax_{Personal\ Income} = T_{taxable}\ x\ pPIT\ x\ N_{workers} \tag{13}$$

With:
$Personal\ Income_{nett}$ = Average net labor income in the mining sector/labor (Rp);
$Ave\ Wage$ = Average gross annual wage/labor (Rp);
$Ave\ Health\ IC$ = Average annual health insurance contribution/labor (Rp);
$T_{taxable}$ = Taxable income (Rp);
$T_{deduction}$ = Deduction or non-taxable income (Rp);

$Tax_{Personal\ Income}$ = Total Potential Personal Income Tax in Mining sector (Rp);
$pPIT$ = Personal income tax rate (%);
$N_{workers}$ = Number of workers in Mining's sector (people).

Social Security Paid by the Employer

$$C_{employer} = \sum[I_{Health} + I_{work\ accident} + I_{death}] \quad (14)$$

With:
$C_{employer}$ = Social security paid by employer (Rp/year);
I_{Health} = Health insurance (Rp/year);
$I_{work\ accident}$ = Work accident insurance (Rp/year);
I_{death} = Death insurance (Rp/year).

CFPP Sector

$$Personal\ Income_{nett} = Ave\ Wage - Ave\ Health\ IC \quad (15)$$
$$T_{taxable} = Personal\ Income_{nett} - T_{deduction} \quad (16)$$
$$Tax_{Personal\ Income} = T_{taxable}\ x\ pPIT\ x\ N_{workers} \quad (17)$$

With:
$Personal\ Income_{nett}$ = Average net labor income in the CFPP sector/labor (Rp);
$Ave\ Wage$ = Average gross annual wage/labor (Rp);
$Ave\ Health\ IC$ = Average annual health insurance contribution/labor (Rp);
$T_{taxable}$ = Taxable income (Rp);
$T_{deduction}$ = Deduction or non-taxable income (Rp);
$Tax_{Personal\ Income}$ = Total Potential Personal Income Tax in CFPP sector (Rp);
$pPIT$ = Personal income tax rate (%);
$N_{workers}$ = Number of workers in CFPP's sector (people).

Social Security Paid by the Employer

$$C_{employer} = \sum[I_{Health} + I_{work\ accident} + I_{death}] \quad (18)$$

With:
$C_{employer}$ = Social security paid by employer (Rp/year);
I_{Health} = Health insurance (Rp/year);
$I_{work\ accident}$ = Work accident insurance (Rp/year);
I_{death} = Death insurance (Rp/year).

3. Personal Income Tax

Mining's CIT

$$Mining's\ CI\ = (Q\ coal\ X\ P\ coal) - [(COGS\ coal + Opex\ coal)\ x\ Q\ coal]\ x\ pCIT \tag{19}$$

With:
Q coal = Total coal consumption from CFPP (Mt);
P coal = Reference price of coal (Rp Billion per Mt);
COGS coal = Company's cost of goods sales (Rp Billion per Mt); and
Opex coal = Company's operating expenses (Rp Billion per Mt).
$pCIT$ = Corporate Income Tax rate (%)

CFPP's CIT

$$CFPP's\ CIT = (Q\ CFPP\ X\ T\ CFPP) - [(COGS\ CFPP + Opex\ CFPP)\ x\ Q\ CFPP]\ x\ pCIT \tag{20}$$

With:
Q CFPP = Total sales of electricity (TWh);
T CFPP = Electricity tariff (Rp Billion per TWh);
COGS CFPP = Company's cost of goods sales (Rp Billion per Mt);
Opex CFPP = CFPP's generating expenses (Rp Billion per Mt);
$pCIT$ = Corporate Income Tax rate (%).

4. Mining's Royalty

$$Royalty_{mining} = \sum \left[Q_{coal} + P_{coal} + p_{royalty} \right] \tag{21}$$

With:
Q coal = Total coal consumption from CFPP (Mt);
P coal = Reference price of coal (Rp Billion per Mt);
$pVAT$ = Royalty's coal rate (%).

5. CFPP's Electricity Subsidy

$$Power's\ Electricity\ Subsidy = Q\ Power\ x\ AES \tag{22}$$

With:
Q CFPP = Total sales of electricity (TWh);

AES	= Average Electricity Subsidy (Rp per kWh).

Appendix 3 Employment Analysis Formula

Labor in CFPP Sector

$$L_{CFPP} = IC \ x \ Lc$$
$$L_{CFPP} = IC \ x \ (\frac{Lci}{ICi}) \quad (23)$$

With:

L CFPP	= Number of workers in CFPP (People);
IC	= CFPP's installed capacity (MW);
Lc	= Labor intensity in CFPP (People/MW);
Lci	= Number of workers in CFPP i (People);
ICi	= CFPP i's installed capacity (MW).

Coal Mining Sector:

$$L_{mining} = P \ x \ Lm$$
$$L_{mining} = P \ x \ (\frac{Lmi}{Pi}) \quad (24)$$

With:

L mining	= Number of workers in coal mining (People);
P	= Coal production (Billion Ton);
Lm	= Labor intensity in coal mining (People/Billion Ton);
Lmi	= Number of workers in coal mining i (People);
Pi	= Coal mining i's production (Billion Ton).

Solar PV's Sector

$$L_{pvi} = Pvi \ x \ Lsi \quad (25)$$

With:

Lpv	= Number of workers in solar PV plants installation (People);
Pvi	= Unit of module solar PV installed (unit);
Lsi	= Labor intensity in solar PV installation (People/Unit).

Solar PV's Installations Operating and Management Sector:

$$L_{pvom} = Pvc \; x \; Liom \quad (26)$$

With:

Lpvom = Number of workers in solar PV plant i (People);

Pvc = Solar PV installed capacity (GW);

Liom = Labor intensity in solar PV installations operating and management sector (People/Unit).

Solar PV's Manufacturing Sector

$$L_{pv`} = Pvc \; x \; Lpvc \quad (27)$$

With:

Lpvc = Number of workers in solar panel manufacturing (People);

Pvc = Solar CFPP installed capacity (GW);

Lpvc = Labor intensity in panel manufacturing (People/MW).

Battery Manufacturing Sector

$$L_{b`} = Bc \; x \; Lbc \quad (28)$$

With:

Lb = Number of workers in battery manufacturing (People);

Bc = required battery capacity (GWh);

Lbc = Labor intensity in battery manufacturing (People/GWh).

Appendix 4 GDP Analysis Assumptions

Assumptions	References
CFPP Sector's (CFPP) Gross Value Added	
The CFPP sector's GVA in this estimation is limited to on-grid CFPP's electricity production and does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)

Assumptions	References
The projection of CFPP's electricity production is based on the scenarios from the RUKN 2023-2060 (2024) and the JETP CIPP (2023).	Analyzed from: RUKN 2023-2060 (2024); and JETP CIPP (2023).
The output value of CFPP estimated from the electricity tariff, the government subsidy, and the compensation income of PLN's due to the lack of the economical price of electricity.	Analyzed from PLN's Annual Report
The projection of electricity tariff is assumed to be constant based on the average of the last 10 years.	Analyzed from PLN's Annual Report
The projection of electricity subsidy and compensations is assumed to be constant based on the average of the last 5 years.	Analyzed from PLN's Annual Report
The intermediary costs only account for expenses directly related to production, such as the coal input cost, the purchased electricity cost, the leases, and the maintenance cost.	UN SNA (2008); PLN's Annual Report
The projection of intermediary consumption cost is assumed to be constant based on the average of the last 5 years.	Analyzed from PLN's Annual Report
Coal Mining's Gross Value Added	
The coal mining's GVA is limited to coal production and does not include changes in inventory.	UN SNA (2008)
The production of coal is assumed to be followed the demand for on-grid CFPP's input.	Clark and Zhang (2022)
The projection of CFPP's coal input is estimated based on the ratio of electricity production to PLN's CFPP coal input on average for the last 5 years.	Analyzed from PLN's Annual Report
The output value of coal mining is calculated based on the coal DMO price set by the Ministry of Energy and Mineral Resources (KESDM), which is USD 70 per metric ton (mt).	Ministry of Energy and Mineral Resources
The projection of DMO price of coal is assumed to be constant based on the average of the last 5 years.	Analyzed from Ministry of Energy and Mineral Resources
The calculation uses the annual middle exchange rate to convert the coal DMO price into Rupiah.	Bank of Indonesia
The projection of annual middle exchange rate from USD to IDR is assumed to be constant based on the average of the last 5 years.	Analyzed from Bank of Indonesia
The intermediary costs only account for expenses directly related to production, such as coal mining service costs, transportation costs, stockpile costs, material and equipment rental costs, as well as maintenance and repair costs.	UN SNA (2008); Top 10 Coal Mining Company's Annual Report

Assumptions	References
The projection of intermediary consumption cost is assumed to be constant based on the average of the last 5 years.	Analyzed from Top 10 Coal Mining Company's Annual Report
CFPP Sector's (Solar PV) Gross Value Added	
The CFPP sector's GVA in this estimation is based on the on-grid solar PV electricity production and does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
The projection of solar PV's electricity production is based on the government planning and also account as well as additional production to replace CFPP production.	Analyzed from: RUKN 2023-2060 (2024); JETP CIPP (2023); and CORE Indonesia (2025)
The output value of solar PV estimated from the global electricity tariff (from levelized cost of electricity) due to the lack of the domestic electricity tariff. The projection of solar PV electricity tariff is assumed to be decline at 4 percent annually.	Analyzed from IRENA (2023)
The government subsidies for solar PV electricity are assumed to remain constant at 10 percent of the electricity tariff due to the lack of the domestic economical price of solar PV electricity.	CORE Indonesia (2025)
The intermediary costs referred from the global cost of electricity due to the lack of the domestic solar PV company. It only account of expenses directly related to production, such as the maintenance of spare parts cost, the operational utilities cost, and the insurance cost.	UN SNA (2008); IRENA (2023)
The projection of intermediary cost is assumed to be decline at 2.3 percent annually.	Analyzed from IRENA (2023)
The calculation uses the annual middle exchange rate to convert the electricity tariff and intermediary cost into Rupiah.	Bank of Indonesia
The projection of annual middle exchange rate from USD to IDR is assumed to be constant based on the average of the last 5 years.	Analyzed from Bank of Indonesia
Solar Module Industry's Gross Value Added	
The solar module industry's GVA in this estimation is based on the on-grid solar PV installed capacity needed in previous estimation, does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
The output value of solar module estimated from the global selling price due to the lack of the domestic selling price of solar module.	Analyzed from IRENA (2023)

Assumptions	References
The projection of solar module selling price is assumed to be decline at 2 percent annually.	Analyzed from IRENA (2023)
The intermediary costs referred from the annual expenses of Jinko Solar Company due to the lack of the domestic solar module company. It only account of raw materials and supporting materials cost, energy and electricity cost, equipment and production machinery cost, production supporting materials, as well as support services and utilities cost.	UN SNA (2008); Jinko Solar Annual Report (2024)
The projection of solar module intermediary cost is assumed to be decline at 2 percent annually.	Analyzed from Jinko Solar Annual Report (2024)
The calculation uses the annual middle exchange rate to convert the selling price and intermediary cost into Rupiah.	Bank of Indonesia
The projection of annual middle exchange rate from USD to IDR and CNY to IDR is assumed to be constant based on the average of the last 5 years.	Analyzed from Bank of Indonesia
Battery Industry's Gross Value Added	
The battery industry's GVA in this estimation is based on the on-grid solar PV electricity production needed in previous estimation, does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
The battery production is estimated to reach only 10 percent of the total solar PV electricity production due to the still low demand from the domestic market.	CORE Indonesia (2025)
The output value of battery estimated from the LG Energy Solution selling price due to the lack of the domestic selling price of battery.	LG Energy Solution Annual Report (2024)
The projection of battery selling price is assumed to be decline at 6 percent annually.	Analyzed from IRENA (2017)
The intermediary costs referred from the annual expenses of LG Energy Solution Company due to the lack of the domestic solar module company. It only account of raw materials and supporting materials cost, energy and electricity cost, equipment and production machinery cost, production supporting materials, as well as support services and utilities cost.	UN SNA (2008); LG Energy Solution Annual Report (2024)
The projection of battery intermediary cost is assumed to be decline at 6 percent annually.	Analyzed from IRENA (2017)
The calculation uses the annual middle exchange rate to convert the selling price and intermediary cost into Rupiah.	Bank of Indonesia
The projection of annual middle exchange rate from KRW to IDR is assumed to be constant based on the average of the last 5 years.	Analyzed from Bank of Indonesia

Appendix 5 Fiscal Analysis Assumptions

Assumptions	References
CFPP Sector's Value Added Tax	
The production of coal is assumed to be followed the demand for on-grid CFPP's input.	Clark and Zhang (2022)
The projection of CFPP's coal input is estimated based on the ratio of electricity production to PLN's CFPP coal input on average for the last 5 years.	Analyzed from PLN's Annual Report
The calculation of VAT on coal follows the input tax and output tax approach	Nabila & Muhasan (2021)
The assumed coal price benchmark is HBA II	Bureau of Budget Analysyis and State Budget Implementation
The calculated cost represents the cost of goods sold (COGS), based on the average of the ten largest listing coal company	CORE Indonesia (2024)
The applicable VAT rate is 10% - 11%	Ministry of Finance (2024)
CFPP Sector's Personal Income Tax	
The workforce represents employees in the Coal-Fired Power Plant (CFPP) sector over the past 5 years. The number of workers in a CFPP refers to the workforce employed while the CFPP is operational.	Clark and Zhang (2022)
The average wage refers to salaries in the CFPP sector compared to 17 economic sectors over the past 5 years and is projected using Compound Annual Growth Rate (CAGR).	Central Bureau of Statistic (2024)
Social security calculations are limited to BPJS Health Insurance, work accident insurance, and death benefits.	Ministry of Labor (2024)
The determination of Non-Taxable Income (PTKP) assumes a single person who is unmarried and has no dependents.	CORE Indonesia (2024)
The tax rate refers to Income Tax Article 21 with a progressive taxation scheme.	Ministry of Finance (2024)
CFPP Sector's Corporate Income Tax	
The production of coal is assumed to be followed the demand for on-grid CFPP's input.	Clark and Zhang (2022)
The projection of CFPP's coal input is estimated based on the ratio of electricity production to PLN's CFPP coal input on average for the last 5 years.	Analyzed from PLN's Annual Report

Assumptions	References
Corporate Income Tax refers to the calculation of corporate income tax at a rate of 22%	Ministry of Finance (2024
Mining Sector's Value Added Tax	
The production of coal is assumed to be followed the demand for on-grid CFPP's input.	Clark and Zhang (2022)
The projection of CFPP's coal input is estimated based on the ratio of electricity production to PLN's CFPP coal input on average for the last 5 years.	Analyzed from PLN's Annual Report
The calculation of VAT on coal follows the input tax and output tax approach	Nabila & Muhasan (2021)
The assumed coal price benchmark is HBA II	Bureau of Budget Analysyis and State Budget Implementation
The calculation uses the annual middle exchange rate to convert the selling price into Rupiah.	Bank of Indonesia
The calculated cost represents the cost of goods sold (COGS), based on the average of the ten largest listing coal company	CORE Indonesia (2024)
The applicable VAT rate is 10% - 11%	Ministry of Finance (2024)
Mining Sector's Personal Income Tax	
The workforce represents employees in the Mining sector over the past 5 years. The number of workers in a CFPP refers to the workforce employed while the CFPP is operational.	Clark and Zhang (2022)
The average wage refers to salaries in the Mining sector compared to 17 economic sectors over the past 5 years and is projected using Compound Annual Growth Rate (CAGR).	Central Bureau of Statistic (2024)
Social security calculations are limited to BPJS Health Insurance, work accident insurance, and death benefits.	Ministry of Labor (2024)
The determination of Non-Taxable Income (PTKP) assumes a single person who is unmarried and has no dependents.	CORE Indonesia (2024)
The tax rate refers to Income Tax Article 21 with a progressive taxation scheme.	Ministry of Finance (2024)
Mining Sector's Corporate Income Tax	

Assumptions	References
Corporate Income Tax refers to the calculation of corporate income tax at a rate of 22% of profits	Ministry of Finance (2024)
Mining Sector's Royalty Revenue	
Coal quality is assumed to have medium calorific content, therefore Reference Coal Price II (Harga Batubara Acuan II) is used as the benchmark	Ministry of Finance (2024)
The average coal price over the 5-year period is less than 70 USD, therefore a royalty rate of 7% is applied	Government Regulation No. 26 of 2022 Concerning Types and Tariffs of Non-Tax State Revenue Types (2025)
Electricity Subsidy	
The electricity subsidy and compensation data come from the State Budget Financial Reports	Ministry of Finance (2023)
The total electricity calculations only include electricity generated from coal-fired power plants (CFPP)	CORE Indonesia (2025)
Value Added Tax on Solar PV, Solar Module Industry, and Battery Industry	
The battery industry's production in this estimation is based on the on-grid solar PV electricity production needed in previous estimation, does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
The Solar PV sector in this estimation is based on the on-grid solar PV electricity production and does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
The solar module industry's production in this estimation is based on the on-grid solar PV installed capacity needed in previous estimation, does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
The cost of good sold operational cost referred from the annual expenses of Jinko Solar Company due to the lack of the domestic solar module company.	UN SNA (2008); Jinko Solar Annual Report (2024)
The cost of good sold and operational cost referred from the global cost of electricity due to the lack of the domestic solar PV company.	UN SNA (2008); IRENA (2023)

Assumptions	References
The cost of good sold and operational cost referred from the annual expenses of LG Energy Solution Company due to the lack of the domestic solar module company.	UN SNA (2008); LG Energy Solution Annual Report (2024)
The output value of solar module estimated from the global selling price due to the lack of the domestic selling price of solar module.	Analyzed from IRENA (2023)
The output value of solar PV estimated from the global electricity tariff (from levelized cost of electricity) due to the lack of the domestic electricity tariff. The projection of solar PV electricity tariff is assumed to be decline at 4 percent annually.	Analyzed from IRENA (2023)
The calculation uses the annual middle exchange rate to convert the selling price, cost of good sold, and operational cost into Rupiah.	Bank of Indonesia
The projection of solar module selling price is assumed to be decline at 2 percent annually.	Analyzed from IRENA (2023)
The projection of solar PV's electricity production is based on the government planning and also account as well as additional production to replace CFPP production.	Analyzed from: RUKN 2023-2060 (2024); JETP CIPP (2023); and CORE Indonesia (2025)
The projection of battery selling price is assumed to be decline at 6 percent annually.	Analyzed from IRENA (2017)
The battery production is estimated to reach only 10 percent of the total solar PV electricity production due to the still low demand from the domestic market.	CORE Indonesia (2025)
The calculation of VAT on coal follows the input tax and output tax approach	Nabila & Muhasan (2021)
The applicable VAT rate is 10% - 11%	Ministry of Finance (2024)
CorporateIncome Tax on Solar PV, Solar Module Industry, and Battery Industry	
The government subsidies for solar PV electricity are assumed to remain constant at 10 percent of the electricity tariff due to the lack of the domestic economical price of solar PV electricity.	CORE Indonesia (2025)

Assumptions	References
The applicable Corporate Income Tax rate is 22%	Ministry of Finance (2024)
Personal Income Tax on Solar PV, Solar Module Industry, and Battery Industry	
The workforce represents projection of ifemployees in the solar modul and battery manufacturing sector and solar pv sector. The number of workers in a CFPP refers to the workforce employed while the CFPP is operational.	Clark and Zhang (2022)
The average wage refers to salaries in the Mining sector compared to 17 economic sectors over the past 5 years and is projected using Compound Annual Growth Rate (CAGR).	Central Bureau of Statistic (2024)
Social security calculations are limited to BPJS Health Insurance, work accident insurance, and death benefits.	Ministry of Labor (2024)
The determination of Non-Taxable Income (PTKP) assumes a single person who is unmarried and has no dependents.	CORE Indonesia (2024)
The tax rate refers to Income Tax Article 21 with a progressive taxation scheme.	Ministry of Finance (2024)
Solar PV' Electricity Subsidy	
The output value of solar PV estimated from the global electricity tariff (from levelized cost of electricity) due to the lack of the domestic electricity tariff. The projection of solar PV electricity tariff is assumed to be decline at 4 percent annually.	Analyzed from IRENA (2023)
The government subsidies for solar PV electricity are assumed to remain constant at 10 percent of the electricity tariff due to the lack of the domestic economical price of solar PV electricity.	CORE Indonesia (2025)

Appendix 6 Employment Analysis Assumptions

Assumptions	References
CFPP Sector's Employment	
The number of workers in a CFPP refers to the workforce employed while the CFPP is operational.	Clark and Zhang (2022)

Assumptions	References
The number of jobs supported by each CFPP depends on the installed capacity of the plant.	Analyzed from PLN's Annual Report
The projection of production and capacity for national CFPPs is based on the scenarios from the RUKN 2023-2060, and the JETP CIPP (2023).	Analyzed from: RUKN 2023-2060; and JETP CIPP (2023).
The labor intensity in national CFPPs is equal to the 10-year average labor intensity of PLN CFPPs.	CORE Indonesia (2024)
Coal Mining's Employment	
The production of coal is assumed to be followed the coal demand for CFPP's input.	Clark and Zhang (2022)
The projection of CFPP's coal input is estimated based on the ratio of electricity production to PLN's CFPP coal input on average for the last 5 years.	Analyzed from PLN's Annual Report
The labor intensity in national mines is equal to the 10-year average labor intensity of the 12 largest asset mines in Indonesia.	CORE Indonesia (2024)
Solar PV Sector's Employment	
The energy sector's employment in this estimation is based on the on-grid solar PV electricity production and does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
The estimated labor refers to the number of workers required to produce solar power plants based on the projected PLTS production in accordance with the government planning and also account as well as additional production to replace CFPP production.	Analyzed from: RUKN 2023-2060 (2024); JETP CIPP (2023); and CORE Indonesia (2025)
The labor intensity in the solar PV generation sector is calculated based on the workforce required for the installation of a 500 Wp solar panel and the labor needed for operation and management, referring to IRENA standards.	Analyzed from IRENA (2023)
Solar Module Industry's Employment	
The solar module industry's employment in this estimation is based on the on-grid solar PV installed capacity needed in previous estimation, does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
Labor intensity in module production is calculated based on the number of workers required to manufacture solar modules per gigawatt, referring to Jinko Solar Company's production standards.	Analyzed from Jinko Solar

Assumptions	References
	Annual Report (2024)
Battery Industry's Employmnet	
The battery industry's Employment in this estimation is based on the on-grid solar PV electricity production needed in previous estimation, does not include change in inventory, and transmission or distribution activity.	UN SNA (2008)
The battery production is estimated to reach only 10 percent of the total solar PV electricity production due to the still low demand from the domestic market.	CORE Indonesia (2025)
Labor intensity in battery cell production is calculated based on the number of workers required to manufacture battery cells per gigawatt, referring to LG Energy Solution's production standards.	LG Energy Solution Annual Report (2024)

Appendix 7 Results of GDP Impact

Table 3 GDP Value Impact Across Scenarios (Trillions of Rupiah)

Scenario	Sector	2024-2030	2031-2040	2041-2050	2051-2060
BaU	Coal-fired CFPP Plant	1,227.5	2,338.2	3,152.3	3,465.3
	Coal Mining	761.5	1,450.5	1,995.5	2,149.7
	Solar Photovoltaic	0.0	0.0	0.0	0.0
	Solar Module Manufacture	0.0	0.0	0.0	0.0
	Battery Manufacture	0.0	0.0	0.0	0.0
Phase Down	Coal-fired CFPP Plant	789.5	1,202.6	829.7	112.5
	Coal Mining	1,272.7	1,938.6	1,337.5	181.3
	Solar Photovoltaic	148.7	734.3	1,445.1	1,448.1
	Solar Module Manufacture	222.9	1,414.2	3,657.8	4,965.1
	Battery Manufacture	26.6	116.1	201.9	184.9
Phase Out	Coal-fired CFPP Plant	518.8	630.9	288.2	0.0
	Coal Mining	836.4	1,017.0	464.7	0.0
	Solar Photovoltaic	706.0	1,633.9	2,127.2	1,753.0
	Solar Module Manufacture	943.4	2,721.5	4,669.1	5,146.8
	Battery Manufacture	111.9	229.9	259.9	192.6

Table 4 GDP Contribution Impact Across Scenarios (%)

Scenario	Sector	2024-2030	2031-2040	2041-2050	2051-2060
BaU	Coal-fired CFPP Plant	1.2	1.2	1.2	1.0
	Coal Mining	0.7	0.7	0.7	0.6
	Solar Photovoltaic	n.a	n.a	n.a	n.a

	Solar Module Manufacture	n.a	n.a	n.a	n.a
	Battery Manufacture	n.a	n.a	n.a	n.a
Phase Down	Coal-fired CFPP Plant	1.2	1.0	0.5	0.1
	Coal Mining	0.8	0.6	0.3	0.1
	Solar Photovoltaic	0.1	0.4	0.5	0.4
	Solar Module Manufacture	0.2	0.7	1.3	1.4
	Battery Manufacture	0.0	0.1	0.1	0.1
Phase Out	Coal-fired CFPP Plant	0.8	0.5	0.2	0.0
	Coal Mining	0.5	0.3	0.1	0.0
	Solar Photovoltaic	0.7	0.8	0.8	0.5
	Solar Module Manufacture	0.9	1.3	1.7	1.5
	Battery Manufacture	0.1	0.1	0.1	0.1

Appendix 8 Results of Fiscal Impact

Table 5 Average Annual Fiscal Revenue from Coal as Fuel for Domestic CFPP Consumption (Billions of Rupiah)

Scenario	Sector	2024-2030	2031-2040	2041-2050	2051-2060
BaU	Value Added Tax	14.057	18.966	26.453	29.372
	Personal Income Tax	11	30	96	834
	Social Contribution	94	127	274	929
	Royalty (PNBP)	8.949	12.040	15.089	18.594
	Corporate Income Tax (CIT)	27.923	37.570	47.082	58.020
Phase Down	Value Added Tax	16.001	17.071	11.730	1.550
	Personal Income Tax	11	27	32	6
	Social Contribution	94	117	98	15
	Royalty (PNBP)	10.173	10.847	7.483	1.014
	Corporate Income Tax (CIT)	31.743	33.846	23.350	3.165
Phase Out	Value Added Tax	10.463	8.883	3.977	-14
	Personal Income Tax	7	14	11	0
	Social Contribution	61	61	33	0
	Royalty (PNBP)	6.685	5.690	2.600	0
	Corporate Income Tax (CIT)	20.860	17.755	8.112	0

Table 6 Average Annual Fiscal Revenue from CFPP (Billions of Rupiah)

Scenario	Sector	2024-2030	2031-2040	2041-2050	2051-2060
BaU	Value Added Tax	34.779	46.795	58.641	72.265
	Personal Income Tax	9	43	409	2.265
	Social Contribution	60	90	249	1.165

	Corporate Income Tax (CIT)	11.034	14.847	18.605	22.928
Phase Down	Value Added Tax	40.940	43.653	30.116	4.082
	Personal Income Tax	11	45	162	31
	Social Contribution	68	97	103	17
	Corporate Income Tax (CIT)	12.544	13.375	9.227	1.251
Phase Out	Value Added Tax	26.904	22.900	10.463	0
	Personal Income Tax	7	29	71	0
	Social Contribution	45	62	46	0
	Corporate Income Tax (CIT)	8.243	7.016	3.206	0

Table 7 Average Annual Subsidies and Electricity Compensation for CFPP (Billions of Rupiah)

Scenario	2024-2030	2031-2040	2041-2050	2051-2060
BaU	105.168	141.503	197.030	198.821
Phase Down	119.554	127.474	177.327	11.920
Phase Out	46.073	39.215	17.917	0

Table 8 Average Annual Fiscal Revenue from Modul's Industry (Billions of Rupiah)

Scenario	Sector	2024-2030	2031-2040	2041-2050	2051-2060
Phase Down	Value Added Tax	3.909	17.360	44.909	60.965
	Personal Income Tax	0,00	0,00	0,25	1,05
	Social Contribution	0,44	2,97	11,929	24,957
	Corporate Income Tax (CIT)	7.818	34.720	89.818	121.929
Phase Out	Value Added Tax	16.544	33.407	57.324	63.196
	Personal Income Tax	0,00	0,00	0,31	1,08
	Social Contribution	2	6	15,094	25,745
	Corporate Income Tax (CIT)	33.087	66.815	114.648	126.392

Table 9 Average Annual Fiscal Revenue from Battery's Industry (Billions of Rupiah)

Scenario	Sector	2024-2030	2031-2040	2041-2050	2051-2060
Phase Down	Value Added Tax	67	204	354	60.965
	Personal Income Tax	0	1	122	505
	Social Contribution	10	67	283	601
	Corporate Income Tax (CIT)	8.181	24.967	43.428	39.771
Phase Out	Value Added Tax	280	403	456	338
	Personal Income Tax	0	2	151	518
	Social Contribution	42	129	364	622
	Corporate Income Tax (CIT)	34.390	49.443	55.905	41.419

Table 10 Average Annual Fiscal Revenue from Solar PV (Billions of Rupiah)

Scenario	Sector	2024-2030	2031-2040	2041-2050	2051-2060
Phase Down	Value Added Tax	15.556	68.462	163.328	198.792
	Personal Income Tax	21	376	2.474	7.256
	Social Contribution	1.001	7.968	37.898	94.116
	Corporate Income Tax (CIT)	3.422	15.062	35.932	43.734
Phase Out	Value Added Tax	65.956	131.882	209.021	206.448
	Personal Income Tax	92	673	3.107	7.460
	Social Contribution	4.269	14.720	47.800	96.898
	Corporate Income Tax (CIT)	14.510	29.014	45.985	45.419

Table 11 Average Annual Subsidies for Solar PV Installation (Billions of Rupiah)

Scenario	2024-2030	2031-2040	2041-2050	2051-2060
Phase Down	112	243	627	994
Phase Out	226	412	787	1.027

Appendix 9 Results of Employment Impact

Table 12 Employment Impact Across Scenarios (Labor)

Scenario	Sector	2024-2030	2031-2040	2041-2050	2051-2060
BaU	Coal-fired CFPP Plant	17,482	20,323	24,402	24,840
	Coal Mining	23,976	31,970	43,102	47,381
	Solar Photovoltaic	n.a	n.a	n.a	n.a
	Solar Module Manufacture	n.a	n.a	n.a	n.a
	Battery Manufacture	n.a	n.a	n.a	n.a
Phase Down	Coal-fired CFPP Plant	17,236	16,988	11,979	1,432
	Coal Mining	24,860	26,507	18,287	2.479
	Solar Photovoltaic	201,961	1,476,788	4,850,492	8,054,455
	Solar Module Manufacture	179	1364	4285	7041
	Battery Manufacture	86,406	658,627	206,5393	3,393,460
Phase Out	Coal-fired CFPP Plant	11,447	11,147	5,602	0,000
	Coal Mining	16,337	13,905	6,353	0,000
	Solar Photovoltaic	870,320	2,968,373	6,232,929	8,330,820
	Solar Module Manufacture	761	2,595	5,448	7,281
	Battery Manufacture	0.1	0.1	0.1	0.1

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CENTER OF REFORM ON ECONOMICS

Gedung CORE Indonesia
Jl. Tebet Barat Dalam Raya No. 76A, Jakarta Selatan, Indonesia 12810
021-50101414 info@coreindonesia.org