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Forecasting Coal Consumption Reduction for Climate Change

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ABSTRACT

Research Originality: This study uniquely examines how reducing coal consumption could mitigate climate change and help achieve the Sustainable Development Goals by 2030.

Research Objectives: This study investigates the impact of reducing coal consumption on climate change and on achieving the Sustainable Development Goals in Indonesia, a major coal exporter, as well as in China and India, which are expected to become major coal importers by 2030.

Research Methods: This study employs a basic panel regression model to analyze data from 2015 to 2024, and uses an ARIMA method to forecast progress toward the Sustainable Development Goals by 2030.

Empirical Results: The findings highlight the urgent need for Indonesia, China, and India to shift to clean, renewable energy to meet the Sustainable Development Goals by 2030, which aim to reduce emissions.

Implications: This study recommends that the governments of Indonesia, China, and India should increase their use of renewable energy sources more consistently.

Keywords:

global warming; emission reduction; renewable energy; clean energy; energy transition

How to Cite:

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INTRODUCTION

The energy transition plays a crucial role in achieving Sustainable Development Goals 7 and 13. In the National Long-Term Development Plan, policies supporting a fair transition to new and renewable energy sources are part of efforts to promote low-carbon growth. This transition ensures that the benefits and risks of moving toward a more sustainable energy future are shared fairly among all affected communities. Previous studies have shown mixed results on how to achieve these development goals. Successfully achieving them will require adopting new methods that promote environmental protection and sustainable practices (Ansell et al., 2022; Küfeoğlu, 2022).

Development Goals suggest a country-led implementation process. However, the success of these initiatives depends on setting sustainability targets that are compatible across different sectors and levels (Moallemi et al., 2020; Shrivastava et al., 2020). It is important to recognize that Sustainable Development Goals 7 and 13 focus on urgent actions needed to fight climate change and its harmful impacts: Clean and Affordable Energy, which aims to ensure universal access to affordable, reliable, sustainable, and modern energy services for everyone.

The literature on climate change has demonstrated an increasing awareness of the need to connect climate change with sustainable development. The findings of this study emphasize the effectiveness of nature-based solutions (NBS) in tackling global challenges. It analyzed 132 documents from Scopus and Web of Science (WoS). The study observed a significant rise in research output, indicating that NBS are becoming more important. The analysis also found that India, Italy, and the UK are among the top countries conducting research. However, there are notable differences in the level of contribution across countries, with African nations contributing less than others (Okolie et al., 2025).

Another study found that transitioning to a renewable energy economy involves more than just shutting down coal-fired power plants; it also requires implementing strategies to reduce the economic and social risks inherent in the supply chain. However, the new regulation remains focused on technology, primarily using metrics such as coal use, power generation, and emissions reductions to measure success. It does not address what will happen to workers who lose their jobs when coal plants close, nor does it provide a way for local communities to participate in decision-making. Climate change is a complex and urgent global issue that has gained significant attention in recent years (Brady, 2020).

Over the years, climate change has significantly affected both the natural environment and society, with both positive and negative impacts. Studies in other countries show that low-carbon transitions are especially difficult in coal regions. There are not only technological and economic challenges but also deep socio-political and cultural barriers to breaking free from carbon lock-in. Changing these regions involves destabilizing and reshaping high-carbon systems, often requiring structural shifts across technological, socioeconomic, political, and cultural areas (Mangalagiu et al., 2025). Those involved find adding capacity to be a significant challenge. Recent studies in India and China,

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two major coal importers, indicate that coal consumption and trade openness greatly affect CO_2 emissions in both the short and long term. An analysis of India's and China's plans shows that each country aims to reduce CO_2 emissions from its power sector by adopting clean coal technology. The analysis indicates that clean technology has substantial potential in this area, as it can accelerate the development of coal technology (Pan et al., 2024; Xu et al., 2024).

This study uses Indonesia, a major coal exporter, as a case study to explore ways to reduce carbon emissions and assess the impact of phasing out coal in the power and upstream sectors of developing coal-producing countries. As one of the fastest-growing economies in Southeast Asia, Indonesia faces a significant challenge in balancing its energy needs with efforts to lower greenhouse gas emissions. Energy has become an increasingly strategic commodity, and supply uncertainty could threaten economic independence and security (Gulagi et al., 2025; Li et al., 2025; Massagony et al., 2025).

Indonesia was selected for this study because it is an emerging country experiencing rapid growth in electricity generation, with coal-fired power plants responsible for 60% of this increase. It is also the world's fifth-largest coal producer and holds a significant share of global coal reserves. Additionally, Indonesia must recognize the importance of the coal sector to the mining industry's income. It has contributed 80% of the total income over the past decade. Furthermore, the coal sector has added 1.5–2% to the national income (Handayani et al., 2025; Munawir et al., 2025; Reyseliani et al., 2024a; Wollff, 2023). Coal revenues account for about 35% of East Kalimantan's income and between 19% and 26% of South Kalimantan's income.

In 2020, the power generation sector remained the largest consumer of coal. Indonesia's total power capacity was 72.8 GW that year, with coal (50.4%), natural gas (24.2%), and oil (11%) accounting for the majority of installed capacity. Additionally, approximately 33 GW of coal-fired power plant capacity was under construction and in active development (Gulagi et al., 2025; Jermain & Pilcher, 2023; Reyseliani et al., 2024b). According to the National Energy Policy (NEP) roadmap, coal is expected to account for about 30 percent of the national energy mix by 2025, decreasing to around 25 percent by 2050. Since 2023, Indonesia has implemented a series of energy transition policies that are expected to affect domestic coal consumption. The government aims to gradually reduce the capacity and electricity generation from coal-fired power plants. Indonesia is actively working to cut coal consumption through various strategies, including transitioning to renewable energy sources and boosting energy efficiency (Ali & Kim, 2024; Massagony et al., 2025; Shah et al., 2024).

Moreover, this study focuses on China and India, as recent research shows that these countries' coal use and openness to trade significantly influence their CO_2 emissions both in the short and long term. Both nations are major importers of coal from Indonesia (Li & Haneklaus, 2022; Li et al., 2012). An analysis of India's and China's plans indicates that both countries aim to reduce CO_2 emissions from their power sectors by adopting clean coal technology. The analysis suggests that clean technology plays a key role in accelerating the development of coal technology in India and China (Agrawal et al., 2024; Chen et al., 2022; Sun & Zuo, 2025; Wu et al., 2024; Zhang et al., 2024). This idea is interesting and could be practiced in Indonesia.

The originality of this research lies in its examination of the potential impact of reducing coal use on climate change and helping achieve Sustainable Development Goals 7 and 13 by 2030. It focuses on Indonesia, a key coal exporter, along with China and India, major coal importers. The study fills a gap in existing research by predicting how shifting from coal to renewable energy could influence climate change and progress toward SDGs 7 and 13, especially in Indonesia, China, and India. Its goal is to analyze how reducing coal use might affect climate change and progress on the SDGs in these countries by 2030. The results are expected to identify ways to lower carbon emissions while boosting renewable energy use, offering policymakers valuable insights.

METHODS

This study forecasts a decrease in carbon emissions using a projection method that combines two complementary analytical techniques: panel regression and ARIMA models. First, panel regression was used to analyze the respective impacts of coal and renewable energy consumption on climate change from 2015 to 2024. The study utilizes panel data from Indonesia, China, and India spanning 2015 to 2024, marking the start of the Sustainable Development Goals period, to assess current conditions. The panel regression model uses longitudinal data to capture temporal and spatial variations in carbon emissions across countries. A second data set covers the years 2025 to 2030, indicating the end of the Sustainable Development Goals period, for predicting future conditions.

Renewable energy, mainly from solar, wind, and hydro sources, is crucial for fighting climate change by replacing fossil fuels, which are the primary source of greenhouse gases that trap heat. Switching to these clean sources cuts carbon emissions because renewables produce minimal emissions during operation. This helps limit global warming, improve air quality, and promote sustainability, with over 90% of new power capacity in 2024 coming from renewable sources (Babaremu et al., 2025; Nwagu, Ujah, Kallon, & Aigbodion, 2025; Okolie, Danso-Abbeam, Ogundeji, Owolabi, & Kunguma, 2025). Because of this, the study focuses on two variables—coal energy consumption and renewable energy sources—to analyze how reducing coal use and increasing renewable energy sources, such as solar and wind power, affect carbon emission forecasts in Indonesia, China, and India. The study also emphasizes the need for more accurate climate modeling to meet the research objectives (see Table 1).

Forecasting is a technique for predicting the future. This research examines forecasting conditions in Indonesia, China, and India, focusing on how reducing coal consumption and increasing renewable energy use will affect carbon emissions forecasts for 2025-2030. The Autoregressive Integrated Moving Average (ARIMA) method is employed to analyze time series data. This medium-term forecasting approach generally yields more accurate results than other methods. The ARIMA model is one example of a technique suitable for analyzing time series data.

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Table 1. Operational Variables

Variables	Definitions	Measurements	Sources
Climate Change	Total carbon emissions from energy, in million tons of carbon dioxide	Million tons of carbon dioxide	The Energy Institute
Coal Energy Consumption	The total amount of energy consumed from coal in one year	Exajoules	The Energy Institute
Renewable Energy Consumption	The total amount of renewable energy consumed in one year	Exajoules	The Energy Institute

The above method aims to analyze the impact of reducing coal consumption and increasing renewable energy sources, such as solar and wind power, on carbon emission forecasts. This will help us predict whether the Sustainable Development Goals will be achieved by 2030 and address the research objectives of this study. This approach offers different perspectives on how changes in energy substitution might influence future emissions. It is expected to produce more precise estimates of potential emission reductions, thereby aiding policymakers in developing effective climate change strategies for 2025–2030. The formation of the existing condition analysis model in this research is defined as follows:

$$Y_{it} = \alpha_0 + \alpha_1 X_{1it} + \alpha_2 X_{2it} + \varepsilon_{it}$$

Where, α: parameter, i: cross section (Indonesia, China, and India), t: time series (2015-2023), ε: error term.

When estimating panel data regression models, three approaches are typically used: the common effect model (CEM), the fixed effects model (FEM), and the random effects model (REM). If the p-values of the cross-section F-test and the cross-section chi-square test are both greater than or equal to 0.05, the chosen model is the CEM. Conversely, if the p-value is less than 0.05, the FEM is selected. Then, the Hausman test is performed after the Chow test shows the FEM model is better. Also, careful testing is necessary to choose the best model between FEM and REM. The decision depends on the p-value of the random cross-section: if it is above 0.05, REM is used; if it is below, FEM is used. The purpose of the Lagrange Multiplier test is to select the best between the CEM and REM models. If the Breusch-Pagan (BP) cross-sectional value is 0.05 or higher, the CEM is chosen. If it is less than 0.05, the REM is preferred (Ospina, Gondim, Leiva, & Castro, 2023; Pereira da Veiga, Pereira da Veiga, Girotto, Marconatto, & Su, 2024).

The ARIMA model was developed by George E. P. Box and Gwilym M. Jenkins. Model identification relies on the ACF and PACF results from the time series. The ARIMA model works well for short-term forecasting but is less accurate for long-term predictions. It does not consider independent variables when making forecasts and assumes data is stationary. ARIMA uses past and present values of the dependent variable to produce accurate forecasts. Short-term forecasting involves multiple stages.

ARIMA assumes the existence of a combination (p, d, q), where p is the number of AR variables, d is the differencing process that makes the data stationary, and q is the number of MA variables. The first step in analyzing a time series with an ARIMA model is to identify the model. ARIMA models can only be applied to stationary time series. Therefore, the first step is to determine whether the data is stationary. If it is not, determine the order of differencing (d) required to make the data stationary. The next step is to determine the orders p and q of the ARIMA model by interpreting the correlogram of the stationary data. The graph should reveal patterns indicating the presence of these elements. Use the ACF (Autocorrelation Function) and PACF (Partial Autocorrelation Function) coefficients to guide this process. Third, estimate the AR and MA parameters. The ARIMA forecasting method is most effective when it includes both AR and MA parameters. Fourth, perform diagnostic checks to confirm the model specifications, paying close attention to the residual correlogram. The fifth step is to forecast and select the best model. This combined approach of panel regression and ARIMA models enables more precise estimation of carbon emission reductions based on predicted changes in energy use, thereby providing a more accurate means to meet the research objectives.

RESULTS AND DISCUSSION

A series of regression analyses was conducted to assess current conditions in Indonesia, China, and India for this research. A Chow test should be conducted to identify the best model, as shown in Table 2. The FEM model is clearly better than the CEM model (Table 2). The next step to find the best model is to perform a Hausman test. A detailed analysis of the Hausman test results (Table 3) showed that the fixed-effects model (FEM) performs better than the random-effects model (REM). It should be noted that the Lagrange Multiplier test was not performed because the FEM is the most suitable model for interpretation.

Table 2. Chow Test Result

Effect Test	Statistic	d.f	Probability
Cross-Section F	17.582000	2,25	0.0000
Cross-section Chi-Square	26.345950	2	0.0000

Source: Output Eviews

According to Table 3, the Hausman test indicates that the REM model is the best fit. Therefore, we can use the Lagrange Multiplier test to verify that the FEM model is the most suitable panel regression model (Table 4).

Table 3. Hausman Test Result

Test Summary	Chi-Sq. Statistic	Chi-Sq d.f	Probability
Cross-section random	35.163999	35.163999	0.0000

Source: Output Eviews

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The results in Table 4 show that energy consumption in Indonesia, China, and India between 2015 and 2024 significantly influenced climate change. It is clear that these countries are shifting toward renewable energy sources, marking a major change in their energy profiles. This study focused on coal energy use in these nations, which accounts for 96.06609% of the climate change impact. The results of this study are interesting and support those of a previous study. Earlier research found that China's imports of large quantities of coal from Indonesia were contributing to climate change. Since most air pollutants in China originate from coal combustion, it is important to limit coal use to improve the environment. This study uses data from 29 Chinese provinces between 1995 and 2012 to forecast China's coal consumption in 2020. It is believed that China's coal use will continue to grow, but at a slower pace. It is estimated that China will consume around 4.43 billion tonnes of coal by 2020. However, if China's growth rate stays at approximately 7.8% annually, the tipping point for total coal consumption will be reached in 2019, with usage expected to peak at 4.16 billion tonnes (Gosens et al., 2022; Liu et al., 2022).

Table 4. Fixed Effect Model Interpretation

Variable	Coeff.	Std Error	t-Statistic	Prob.
C	559.4204	278.0616	2.011858	0.0551
X1	96.06609	9.741093	9.861941	0.0000
X2	-104.4093	19.71771	5.295203	0.0000

Source: Output Eviews

Moreover, this research offers additional evidence supporting the findings of a previous study conducted in India. That study revealed that India's large-scale coal imports from Indonesia contributed to climate change. It showed that India's expansion of coal power could be linked to several factors. First, the power sector was opened to competition to ensure a reliable supply. This allowed big companies to invest in coal and make long-term profits, especially given the limited support for renewable energy. Second, planned public investments in new coal capacity aim to guarantee long-term electricity availability. Third, coal's importance to the economy in eastern India and the influence of local groups are major reasons why ending coal use is so challenging. Fourth, regulations meant to cut pollution and coal use are ineffective because coal supporters hold significant political influence (Montrone et al., 2021).

This study provides information on the impact of coal consumption in Indonesia, the world's largest coal exporter, as well as in China and India, which are major coal importers. However, because few studies have assessed the environmental effects of the coal industry, this research supports the idea that Indonesia causes environmental damage from coal use. Specifically, the carbon emissions from a 1% increase in coal consumption in developed countries are roughly 6 times higher than those in developing countries. Therefore, the study recommends a gradual, rather than abrupt, phase-out of coal, prioritizing developed countries. The coal phase-out and the removal of fossil fuel subsidies should be implemented first in developed nations or be made more stringent there than in developing economies. Developed nations should reduce their coal consumption by a larger share than developing countries (Alhassan et al., 2024).

The debate over phasing out or reducing coal use is ongoing across the world's economies. Each country has its own views and commitments based on its socioeconomic priorities. Another study found that, in a globalized world, strategies to limit China's total coal consumption should be considered to reduce its coal use. Improving energy efficiency would be an effective way for China (Adebayo, 2023; Orhan et al., 2021). The harmful effects of climate change on the environment require us to accelerate the transition to low-carbon energy sources. The most important step is reducing our dependence on coal since it is the main source of carbon emissions and a key driver of global warming. However, the coal sector is deeply rooted in the country's social and political landscape, making it challenging to reduce reliance on coal (Pandey & Kumar, 2025).

This study also found that increased use of renewable energy can help reduce climate change by (-104.4093%). It supports the findings of another study, which reported that the average cost of solar power in India is now cheaper than the variable cost of many coal-fired power plants (Shrimali, 2020). Renewable energy is a type of energy source that does not emit carbon. The findings show that renewable energy can effectively replace coal, leading to substantial environmental benefits and economic savings. The research confirms previous studies that estimate the effects of switching from coal to renewable energy in China. The results reveal that the reduction in CO_2 emissions from decreased coal use exceeds the increase in CO_2 emissions from renewable energy use (Kocak & Alnour, 2025).

These findings also support the conclusions of a recent study suggesting that the global community is currently pursuing two different strategies to phase out coal. The first strategy involves using gas as a temporary solution during the shift to renewable energy sources. The second strategy involves moving directly from coal to renewable energy. This study also supports earlier research on the transition from coal to clean energy sources. This is crucial because reducing carbon emissions is vital for all countries. Some of these studies have explored ways to cut coal consumption. All of these studies agree that, to lower greenhouse gas emissions, the world must decrease its dependence on coal for electricity. Greenhouse gases are a primary driver of global warming. Achieving this could help the world become carbon-neutral by 2050 (Do & Burke, 2023; Hyun et al., 2023; Jermain & Pilcher, 2023; Moon et al., 2025).

This study also examined forecasting conditions using a series of ARIMA tests, including the ADF test in Table 5, to assess data stationarity. As shown in Table 5, the data-stationarity analysis indicates that the orders are 1 for coal energy consumption and 2 for climate change and renewable energy consumption. Once data stationarity has been established, the next step is to determine the ARIMA model orders p and q using the correlogram, as illustrated in Table 6. As shown in Table 6, this information can serve as the basis for ARIMA forecasting via the automatic method in the review processing application. At this stage, it is concluded that the data are stationary in first differences

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for coal energy consumption and in second differences for climate change and renewable energy consumption.

Table 5. Stationery Test Result

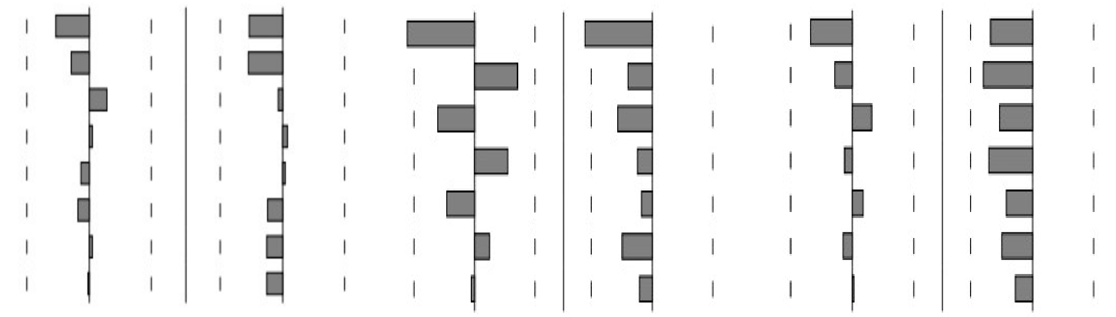
Variable	ADF Test				Decision
	First Difference	Prob.	Second Difference	Prob.	
Y	-3.218275	0.0573	-3.505575	0.0507	Stationer
X1	-3.621467	0.0338	-	-	Stationer
X2	-5.035982	0.0059	-7.022003	0.0012	Stationer

Source: Output Eviews

Therefore, the d element in the ARIMA (p, d, q) model is 1 for coal energy consumption and 2 for climate change and renewable energy consumption. Consequently, the analysis will use the ARIMA (p, 1, q) model for coal energy consumption and the ARIMA (p, 2, q) model for climate change and renewable energy consumption. The next step is to determine the values of p and q.

Table 6. Correlogram Test Results

Y		X1		X2	
Auto Corr.	Partial Corr.	Auto Corr.	Partial Corr.	Auto Corr.	Partial Corr.



Source: Output Eviews 13

Table 7. Selection of the best ARIMA model

Variable	ARIMA Model	AIC	SC	HC	Adjusted R2	Significant Variable	Result
Y	**(0,2,1)**	11.93700	11.96679	11.73607	-0.473062	0	Best Model
	(1,2,1)	12.13413	12.17385	11.86623	0.406934	0	AR(0) MA(1)
	(1,2,0)	12.38848	12.41827	12.18756	-0.058177	0	
X1	**(1,1,0)**	2.032859	2.098600	1.890989	-0.159603	0	Best Model
	(1,1,1)	2.045466	2.133121	1.856306	0.084667	0	AR(0) MA(1)
	(0,1,1)	1.846263	1.912004	1.704393	0.245250	1	
X2	**(0,2,1)**	-2.180462	-2.150671	-2.150671	0.565104	0	Best Model
	(1,2,1)	-2.284765	-2.245044	-2.552666	0.668471	0	AR(0)MA(1)
	(1,2,0)	-2.255290	-2.225499	-2.456215	0.524581	0	

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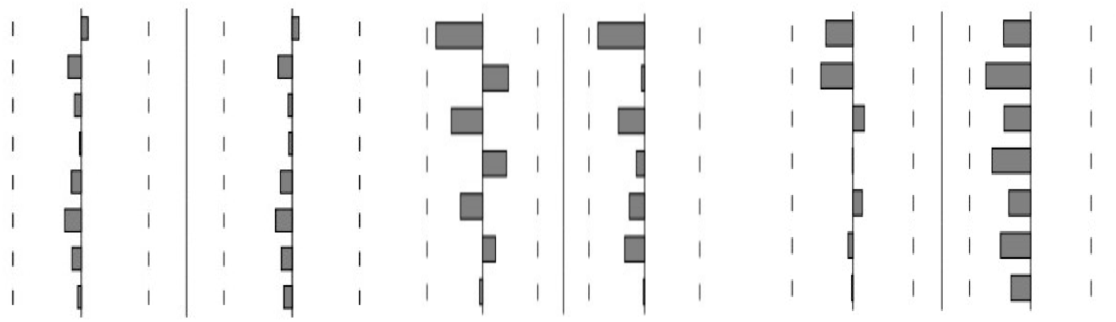
Table 8. Residual Correlogram

Y		X1		X2	
Auto Corr.	Partial Corr.	Auto Corr.	Partial Corr.	Auto Corr.	Partial Corr.



Source: Output Eviews

The goal is to identify the values of p and q in an ARIMA model by generating ACF and PACF diagrams using a correlogram. The autocorrelation function (ACF) involves calculating autocorrelation coefficients, whereas the partial autocorrelation function (PACF) involves calculating partial autocorrelation coefficients. The ACF indicates the value of q, which relates to MA, while the PACF indicates the value of p, which relates to AR. The initial models for coal energy consumption (X1) in EViews are either 0 or 1: (1, 1, 0) or (1, 1, 1). Similarly, the ARIMA models considered are 0, 1, or 2: (0, 2, 1), (1, 2, 1), or (1, 2, 0) for climate change (Y) and renewable energy consumption (X2). To select the best ARIMA model, the AIC, Schwarz criterion (SC), and Hannan-Quinn criterion (HC) will be compared, along with the adjusted R-squared values. The results in Table 7, generated using EViews, suggest that an AR(1) model is preferable for all variables in this study over an MA(0) model.

Based on these recommendations, it is essential to move to the next diagnostic checking phase to verify the adequacy of the model specifications. This will be done through residual correlogram analysis, using the results from the recommended automatic ARIMA model. As shown in Table 8, the residual correlogram for all variables appears random, supported by the ACF and PACF values crossing the designated limit line. This indicates that the recommended model specifications are appropriate.

Table 9. Forecasting Result

Period	Y		X1		X2	
	Million Tons	%	Million Tons	%	Million Tons	%
2025	686.4750	-	810.9500	-	1.520000	-
2026	745.3250	8.57	883.3500	8.93	1.623333	6.80
2027	810.9500	8.80	962.5250	8.96	1.726000	6.32
2028	883.3500	8.93	1048.475	8.93	1.828000	5.91
2029	962.5250	8.96	1141.200	8.84	1.929333	5.54
2030	1048.475	8.93	1240.700	8.72	2.030000	5.22

Source: Output Eviews 13

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Having obtained a satisfactory result from the diagnostic test, the next step is to forecast future trends through 2030, as outlined in Table 9. As illustrated in Table 9, the forecast results, based on an analysis of the current situation, indicate a worsening of climate change conditions for each projection period. The highest level of climate change is expected in 2030 at 1,048,475 million tons, showing an increase of 8.93%. Coal energy consumption rose to 1,240.7 million tons, up 8.72%. The most significant outcome of the forecast is that increasing the use of renewable energy helps prevent climate change. The study demonstrates that renewable energy use in Indonesia, China, and India is projected to rise by 2.03 million tonnes by 2030, a 5.22% increase.

These results support previous research indicating that using low-carbon fossil energy technologies is a crucial way to address climate change today, especially for reducing carbon emissions from coal combustion. Using renewable energy sources to reduce carbon emissions can help lower atmospheric CO_2 levels, benefiting the climate. This approach has been shown to reduce both global warming and extreme weather events (Yang et al., 2025; Yusuf & Ibrahim, 2023). Another study also concluded that transitioning to a 100% clean, renewable energy system is essential to tackling climate change (Fthenakis et al., 2025). The exploration of renewable energy sources, including wind, solar, and hydropower, continues, along with emerging technologies such as hydrogen energy systems and long-duration energy storage, all aimed at decreasing emissions that contribute to climate change (Fthenakis et al., 2025).

This study also supports the findings of a previous study on India's transition from coal to renewable energy. Most experts interviewed in India believe that coal use will continue for the next two decades to ensure energy security and affordability for consumers. At the same time, the analysis considered the lower costs of solar power, which it identified as a major factor in the study. There has also been a rise in the perception of carbon management technologies (Singh et al., 2025; Tiwari et al., 2023). The findings also align with previous research in China, which states that the transition must be guided by a thorough evaluation of technical, economic, and environmental factors.

Additionally, it is essential to develop a metric to prioritize early plant retirement. This study found that 18% of plants consistently perform poorly across all three evaluation criteria. These plants can be considered 'low-hanging fruit', making them suitable for quick retirement. Regarding rapid retirement, existing plants can continue to operate for at least 20 or 30 years. This can be achieved by gradually reducing their use, helping meet the 1.5°C or well below 2°C climate targets. The complete phase-out of these plants is expected to be achieved by 2045 and 2055, respectively (Lv et al., 2025).

In Indonesia, this study supports government policy. In accordance with the Paris Agreement, the Republic of Indonesia has pledged to reach net-zero emissions (NZE) by 2060, and to do so, comprehensive legal policies must be enacted (Massagony et al., 2025). Government policy can promote the transition to renewable energy. This research supports a previous study in Indonesia, which found that the least-cost transition is strongly supported by a carbon tax policy. This intervention also generates revenue for the government, which can be reinvested sustainably in society or used to boost the competitiveness of renewable energy. Carbon taxes and other policies help define the costs, capacity additions, and CO_2 emission reduction spectrum for decarbonizing Indonesia's electricity sector (Ali & Kim, 2024; Halimatussadiah et al., 2024; Shah et al., 2024).

Another study in Germany found that the successful implementation of climate policies depends on public support. Previous research has shown that support for general climate policies is relatively high. However, support for specific measures, such as emission trading systems and carbon taxes, is lower, despite their effectiveness in reducing greenhouse gas emissions and providing incentives to do so (Moon et al., 2025). Finally, in Indonesia, reaching more ambitious climate goals requires a strategic shift from coal to natural gas, combined with the adoption of renewable energy sources. Additional research shows that the country's climate targets could be met through a mix of transitioning from coal to natural gas and increasing the use of renewable energy. Potential synergies between the national electricity company, PLN, and the palm oil industry were also identified, and collaboration between these sectors could greatly enhance the sustainability of both.

CONCLUSION

This study examines the impact of coal consumption in Indonesia, the world's largest coal exporter, and in China and India, two of the world's largest coal importers, which are considering phasing out or reducing their use. The study emphasizes the importance of increasing the use of renewable energy sources, such as solar, wind, and hydropower, to reduce reliance on coal and mitigate the effects of climate change.

These findings have clear policy implications for achieving the Sustainable Development Goals: The governments of Indonesia, India, and China are advised to revise their strategies and adopt renewable energy sources such as solar, wind, and hydropower. These sources are clean and environmentally friendly, helping reduce climate change through their low emissions. However, the transition to renewable energy requires more than just shutting down coal-fired power stations. It also involves strategies to address economic and social issues, such as emission trading systems and carbon taxes, while ensuring local communities can participate in decision-making. The government must also provide support to accelerate the development process through environmental policies.

REFERENCES

Adebayo, T. S. (2023). Trade-off between Environmental Sustainability and Economic Growth through Coal Consumption and Natural Resources Exploitation in China: New Policy Insights from Wavelet Local Multiple Correlation. *Geological Journal*, *58*(4), 1384–1400. https://doi.org/10.1002/gj.4664.

Agrawal, K., Pathak, M., Jana, K., Unni, J., & Shukla, P. (2024). Just Transition Away from Coal: Vulnerability Analysis of Coal Districts in India. *Energy Research and Social Science*, *108,* 103355. https://doi.org/10.1016/j.erss.2023.103355.

Alhassan, A., Ozturk, I., Al-Zyoud, M. F., & Bekun, F. V. (2024). Coal Consumption-Environmental Sustainability Nexus in Developed and Developing Major Coal-Consuming Economies. *Heliyon*, *10*(4), e25619. https://doi.org/10.1016/j.heliyon.2024.e25619.

http://journal.uinjkt.ac.id/index.php/signifikan
https://doi.org/10.15408/sjie.v15i1.49676

Ali, P. O., & Kim, K. N. (2024). Analysis of Indonesia's Priority Selection: Energy Transition, Energy-Related Measures, Mining Governance, and Resource Transition Using The Analytic Hierarchy Process (AHP). *Energy for Sustainable Development, 83,* 101559. https://doi.org/10.1016/j.esd.2024.101559.

Ansell, C., Sørensen, E., & Torfing, J. (2022). Co-Creation for Sustainability: The UN SDGs and the Power of Local Partnership. *Co-Creation for Sustainability: The UN SDGs and the Power of Local Partnership*, 1–241. https://doi.org/10.1108/9781800437982.

Babaremu, K., Olumba, N., Chris-Okoro, I., Chuckwuma, K., Jen, T. C., Oladijo, O., & Akinlabi, E. (2025). Integrating Solar and Wind Energy into the Electricity Grid for Improved Power Accessibility. *Unconventional Resources*, *5*(16), 100129. https://doi.org/10.3390/en15166014.

Chen, H., Liu, K., Shi, T., & Wang, L. (2022). Coal Consumption and Economic Growth: A Chinese City-Level Study. *Energy Economics*, *109,* 105940. https://doi.org/10.1016/j.eneco.2022.105940.

Do, T. N., & Burke, P. J. (2023). Phasing Out Coal Power in a Developing Country Context: Insights from Vietnam. *Energy Policy*, *176,* 113512. https://doi.org/10.1016/j.enpol.2023.113512.

Fthenakis, V. M., Montague, C., Abraham, A., Liu, K., & Jacobson, M. Z. (2025). The Transition to 100% Clean, Renewable Energy. In. Letcher, M., & Fthenakis, V. M (Eds). *Energy and Climate Change: Our New Future*, 575–604. London: Academic Press. https://doi.org/10.1016/B978-0-443-21927-6.00012-X.

Gosens, J., Turnbull, A. B. H., & Jotzo, F. (2022). China's Decarbonization and Energy Security Plans will Reduce Seaborne Coal Imports: Results From an Installation-Level Model. *Joule*, *6*(4), 782–815. https://doi.org/10.1016/j.joule.2022.03.008.

Gulagi, A., Oyewo, A. S., Bogdanov, D., Simamora, P., Tampubolon, A., Pujantoro, M., Gordon, P., Tumiwa, F., & Breyer, C. (2025). Accelerating the Transition from Coal to Renewables in Indonesia to Achieve a Net-Zero Energy System. *IET Renewable Power Generation*, *19*(1), e13188. https://doi.org/10.1049/RPG2.13188.

Halimatussadiah, A., Kruger, W., Wagner, F., Afifi, F. A. R., Lufti, R. E. G., & Kitzing, L. (2024). The Country of Perpetual Potential: Why Is It so Difficult to Procure Renewable Energy in Indonesia? *Renewable and Sustainable Energy Reviews*, *201,* 114627. https://doi.org/10.1016/j.rser.2024.114627.

Handayani, I. G. A. K. R., Yosiana, C., & Kongrawd, S. (2025). Reform of Environmental Approval Policy for Renewable Energy in Indonesia. *Journal of Sustainable Development and Regulatory Issues*, *3*(2), 286–323. https://doi.org/10.53955/jsderi.v3i2.101.

Hyun, M., Cherp, A., Jewell, J., Kim, Y. J., & Eom, J. (2023). Feasibility Trade-Offs in Decarbonising the Power Sector with High Coal Dependence: The Case of Korea. *Renewable and Sustainable Energy Transition*, *3,* 100050. https://doi.org/10.1016/j.rset.2023.100050.

Jermain, D. O., & Pilcher, R. C. (2023). Trusting Clean Energy: Novel Perspectives on Transition Pathways for Coal Phaseouts and Clean Electrification Phase-Ins. *Electricity Journal*, *36*(7), 107318. https://doi.org/10.1016/j.tej.2023.107318.

Kocak, E., & Alnour, M. (2025). The Path to China's Zero-Carbon Target: Implications for the Relationship Between De-Coal, Economic Output, and Carbon Dioxide Emissions. *Sustainable Development*, *33*(1), 100–112. https://doi.org/10.1002/sd.3111.

Küfeoğlu, S. (2022). Emerging Technologies: Value Creation for Sustainable Development. *Sustainable Development Goals Series*, *Part F2738*, 1–510. https://doi.org/10.1007/978-3-031-07127-0.

Li, B., & Haneklaus, N. (2022). The Potential of India's Net-Zero Carbon Emissions: Analyzing the Effect of Clean Energy, Coal, Urbanization, and Trade Openness. *Energy Reports*, *8*, 724–733. https://doi.org/10.1016/j.egyr.2022.01.241.

Li, J., Peng, L., Zhang, J., Wang, Y., Li, Z., Yan, Y., Zhang, S., Li, M., & Xie, K. (2025). Synergetic Mitigation of Air Pollution and Carbon Emissions of Coal-Based Energy: A Review and Recommendations for Technology Assessment, Scenario Analysis, and Pathway Planning. *Energy Strategy Reviews*, *59,* 101698. https://doi.org/10.1016/j.esr.2025.101698.

Li, M., Jin, X., & Tang, Q. (2012). Policies, Regulations, and Eco-Ethical Wisdom Relating to Ancient Chinese Fisheries. *Journal of Agricultural and Environmental Ethics*, *25*(1), 33–54. https://doi.org/10.1007/S10806-010-9288-9.

Liu, K., Chen, Y., & Zheng, W. (2022). Impact of COVID-19 on China's Coal Imports: Effects and Solutions. *Transnational Corporations Review*, *14*(1), 31–45. https://doi.org/10.1080/19186444.2022.2025728.

Mangalagiu, D., Lieu, J., Biddau, F., Martinez Reyes, A., & Witajewska-Baltvilka, B. (2025). Enabling Sustainable Transitions in Coal and Carbon-Intensive Regions: Interdisciplinary Social Science Perspectives. *Global Environmental Change*, *93*, 103022. https://doi.org/10.1016/j.gloenvcha.2025.103022.

Massagony, A., Pandit, R., & White, B. (2025). Political Economy of Energy Policy in Indonesia towards Net Zero Emissions by 2060. *Energy for Sustainable Development*, *88*, 101757. https://doi.org/10.1016/j.esd.2025.101757.

Moallemi, E. A., Malekpour, S., Hadjikakou, M., Raven, R., Szetey, K., Ningrum, D., Dhiaulhaq, A., Bryan, B. A. (2020). Achieving the Sustainable Development Goals Requires Transdisciplinary Innovation at the Local Scale. *One Earth*, *3*(3), 300–313. https://doi.org/10.1016/j.oneear.2020.08.006.

Montrone, L., Ohlendorf, N., & Chandra, R. (2021). The Political Economy of Coal in India – Evidence from Expert Interviews. *Energy for Sustainable Development*, *61*, 230–240. https://doi.org/10.1016/j.esd.2021.02.003.

Moon, S., Lee, J., Kim, J., & Choi, H. (2025). Analysis on the Acceptance of Coal Phase-Out Policy Considering Public Preferences: Policy Implications and Future Direction Based on Empirical Evidence from South Korea. *Energy Economics*, *145*, 108453. https://doi.org/10.1016/j.eneco.2025.108453.

Munawir, Mahidin, Away, Y., Azwar, & Ismail, W. I. N. W. (2025). Mapping and Analysis of Local Potential for New and Renewable Energy and Its Conversion Technology in Aceh-Indonesia. *Renewable and Sustainable Energy Transition*, *8,* 100126. https://doi.org/10.1016/j.rset.2025.100126.

Nwagu, C. N., Ujah, C. O., Kallon, D. V. V., & Aigbodion, V. S. (2025). Integrating Solar and Wind Energy into the Electricity Grid for Improved Power Accessibility. *Unconventional Resources*, *5*, 100129. https://doi.org/10.1016/j.uncres.2024.100129.

Okolie, C. C., Danso-Abbeam, G., Ogundeji, A. A., Owolabi, S. T., & Kunguma, O. (2025). Achieving the Sustainable Development Goals through Nature-based Solutions amidst Climate Change. Evidence from Scopus and Web of Science (WoS) Databases. *Sustainable Futures*, *10*, 100855. https://doi.org/10.1016/j.sftr.2025.100855.

Orhan, A., Adebayo, T. S., Genç, S. Y., & Kirikkaleli, D. (2021). Investigating the Linkage Between Economic Growth and Environmental Sustainability in India: Do Agriculture and Trade Openness Matter? *Sustainability*, *13*(9), 4753. https://doi.org/10.3390/su13094753

Ospina, R., Gondim, J. A. M., Leiva, V., & Castro, C. (2023). An Overview of Forecast Analysis with ARIMA Models during the COVID-19 Pandemic: Methodology and Case Study in Brazil. *Mathematics, 11*(4), 3069. https://doi.org/10.3390/math11143069.

Pan, Y., Jiang, L., & Wang, H. (2024). Cost–Benefit Analysis of the China's Household Coal-to-Electricity Transition: A Case Study on the Beijing Mentougou Area. *Energies*, *17*(23), 5933. https://doi.org/10.3390/en17235933.

Pandey, J. G., & Kumar, A. (2025). Navigating India's Energy Transition: A Systematic Literature Review of Risks in the Coal Phase-Down Process. *Renewable and Sustainable Energy Reviews*, *210*, 115260. https://doi.org/10.1016/j.rser.2024.115260.

Pereira da Veiga, C., Pereira da Veiga, C. R., Girotto, F. M., Marconatto, D. A. B., & Su, Z. (2024). Implementation of the ARIMA Model for Prediction of Economic Variables: Evidence from the Health Sector in Brazil. *Humanities and Social Sciences Communications*, *11*(1), 1068. https://doi.org/10.1057/s41599-024-03023-3.

Reyseliani, N., Pratama, Y. W., Hidayatno, A., Mac Dowell, N., & Purwanto, W. W. (2024a). Power Sector Decarbonisation in Developing and Coal-Producing Countries: A Case Study of Indonesia. *Journal of Cleaner Production*, *454*, 142202. https://doi.org/10.1016/j.jclepro.2024.142202.

Reyseliani, N., Pratama, Y. W., Hidayatno, A., Mac Dowell, N., & Purwanto, W. W. (2024b). Power Sector Decarbonisation in Developing and Coal-Producing Countries: A Case Study of Indonesia. *Journal of Cleaner Production*, *454*, 142202. https://doi.org/10.1016/j.jclepro.2024.142202.

Shah, K. U., Raghoo, P., & Blechinger, P. (2024). Is There A Case for a Coal Moratorium in Indonesia? Power Sector Optimization Modeling of Low-Carbon Strategies. *Renewable and Sustainable Energy Transition*, *5*, 100074. https://doi.org/10.1016/j.rset.2023.100074.

Shrimali, G. (2020). Making India's Power System Clean: Retirement of Expensive Coal Plants. *Energy Policy*, *139*, 111305. https://doi.org/10.1016/j.enpol.2020.111305.

Shrivastava, P., Stafford Smith, M., O'Brien, K., & Zsolnai, L. (2020). Transforming Sustainability Science to Generate Positive Social and Environmental Change Globally. *One Earth*, *2*(4), 329–340. https://doi.org/10.1016/j.oneear.2020.04.010.

Singh, U., Vishwanathan, S. S., Garg, A., Singh, A. K., & Iyer, S. H. (2025). Socio-Technical Feasibility of Coal Transitions in India: Results from Stakeholder Interviews. *Energy and Climate Change*, *6*, 100188. https://doi.org/10.1016/j.egycc.2025.100188.

Sun, C., & Zuo, X. (2025). Sustainable growth like China: The Economic Effects of Clean Coal Power Generation. *Energy Economics*, *151*, 108939. https://doi.org/10.1016/j.eneco.2025.108939.

Tiwari, V., Garg, A., Kapshe, M., Deshpande, A., & Vishwanathan, S. (2023). Assessing Possibilities for Coal Continuance in India Under Climate Constraints. *International Journal of Greenhouse Gas Control*, *122,* 103811. https://doi.org/10.1016/j.ijggc.2022.103811.

Wollff, I. (2023). Coal Resources, Production, and Use in Indonesia. In. Osborne, D (Ed). *The Coal Handbook: Volume 2: Towards Cleaner Coal Utilization, 2nd Edition*, *2*, 361–430. Cambridge: Woodhead Publishing. https://doi.org/10.1016/B978-0-12-824327-5.00008-9.

Wu, H., Liu, J., Hu, X., He, G., Zhou, Y., Wang, X., Liu, Y., Ma, J., & Tao, S. (2024). Fewer than 15% of Coal Power Plant Workers in China Can Easily Shift to Green Jobs by 2060. *One Earth*, *7*(11), 1994–2007. https://doi.org/10.1016/j.oneear.2024.10.006.

Xu, X., Dong, J., Zhong, X., & Xie, D. (2024). Climate Impact of Coal-to-Clean-Energy Shift Policies in Rural Northern China. *Journal of Cleaner Production*, *434*, 139870. https://doi.org/10.1016/j.jclepro.2023.139870.

Yang, W., Wang, B., & Gupta, R. (2025). Coal and Climate Change. In. Letcher, T. M., & Fthenakis, V. M (Eds). *Energy and Climate Change: Our New Future*, 153–194. London: Academic Press. https://doi.org/10.1016/B978-0-443-21927-6.00001-5.

Yusuf, M., & Ibrahim, H. (2023). A Comprehensive Review on Recent Trends in Carbon Capture, Utilization, and Storage Techniques. *Journal of Environmental Chemical Engineering*, *11*(6), 111393. https://doi.org/10.1016/j.jece.2023.111393

Zhang, R., Li, W., Li, Y., & Li, H. (2024). Job Losses or Gains? The Impact of Supply-Side Energy Transition on Employment in China. *Energy*, *308*. https://doi.org/10.1016/j.energy.2024.132804.

http://journal.uinjkt.ac.id/index.php/signifikan
https://doi.org/10.15408/sjie.v15i1.49676