Energy Intensity and Elasticity in Indonesia: Decoupling Dynamics and Progress toward National Energy Targets

Amirul Mahmud[1]
[1] Department of Magister of Electrical Engineering, Christian University of Indonesia, Jakarta, Indonesia
[1] email: amirulmahmud01@gmail.com

[*submitted*: 28-02-2026 | *review*: 11-04-2026 | *published*: 30-04-2026]

***ABSTRACT**: This study evaluates Indonesia's energy-economic trajectory from 2010 to 2024 to determine its alignment with the National Energy Policy (KEN) mandates. Employing a quantitative benchmarking approach, the research utilizes the Tapio decoupling model, energy intensity analysis, and energy elasticity indicators to analyze longitudinal performance. The statistical validity of the findings is confirmed through a Paired Sample T-Test, which reveals a significant discrepancy between actual energy intensity and KEN target trajectories ($p < 0.05$), rejecting the null hypothesis of policy alignment. The results highlight a major structural reversal during the 2022 recovery phase, characterized as a recovery shock, where energy consumption growth disproportionately outpaced economic output. This period resulted in a record-high energy elasticity coefficient of 5.99 and a transition to expansive negative decoupling. Although 2024 data indicates a return toward relative elasticity compliance (0.90), a persistent inefficiency gap remains, with actual energy intensity (98.76 BOE/Billion IDR) standing 16.5% above the prescribed mandates. These findings suggest that Indonesia's economic growth remains fundamentally coupled with energy consumption, exhibiting a significant indicator divergence. To ensure compliance with 2025 targets, targeted policy interventions are required, specifically through mandatory energy efficiency audits in the industrial sector and accelerated fuel-switching strategies in transport.*

***KEYWORDS:** Decoupling Analysis, Energy Efficiency, Energy Elasticity, Energy Intensity, National Energy Policy, Tapio Model*

I. INTRODUCTION

Indonesia faces a significant challenge in aligning its robust economic growth with the efficiency mandates established in the National Energy Policy (Kebijakan Energi Nasional/KEN). Inefficient energy utilization is primarily monitored through energy intensity, which serves as a key indicator of national energy use efficiency [1]. According to Government Regulation No. 79 of 2014, the government targeted a consistent 1% annual reduction in energy intensity and an energy elasticity coefficient (e) of less than 1.0 by 2025 [2]. However, empirical data from 2010 to 2024 reveals high volatility; for instance, while intensity reached a low of 78.37 BOE/Billion Rupiahs in 2021, it experienced a extensive rebound to 98.08 BOE/Billion Rupiahs in 2022, representing a sharp 25.15% increase [3], [4]. This surge in energy consumption—which reached 1,148.486 thousand BOE in 2022—indicates a structural coupling effect where energy demand growth significantly outpaces GDP growth signaling a critical departure from national sustainability goals.

Previous studies have attempted to analyze these dynamics from various perspectives. Ilhaq & Syafitri [5] and Pratiwi [6] utilized econometric models to identify that real GDP per capita and trade openness generally have a negative impact on energy intensity, while foreign direct investment (FDI) often drives it upward. In a more sectoral context, Mukaromah & Widodo [7] found that most ASEAN countries, including Indonesia, experienced expansive negative decoupling, where national income growth remains heavily dependent on fossil-fuel-based electricity. Furthermore, recent global work by Chen et al. [8] highlights that while energy intensity improvements are the primary driver for emission reduction, strong decoupling remains rare and inconsistent across developing economies.

Despite these contributions, a significant research gap persists. Most existing literature focuses on the determinants of intensity using data that concludes at the onset of the pandemic or focuses narrowly on carbon emissions in the power sector. There is a lack of comprehensive, policy-based evaluation that accounts for the post-pandemic recovery phase (2022–2024). Current models often fail to explain the inefficiency gap, which refers to the failure to adopt energy-efficient practices that are economically advantageous, resulting in a disparity between actual energy use and the cost-effective frontier [9]. In the Indonesian context, this gap is exemplified by the sudden economic normalization that led to an elasticity spike of 5.99 in 2022—a phenomenon that contradicts the long-term declining trends observed in earlier studies.

This research addresses these gaps by evaluating Indonesia's energy-economic decoupling status over a 15-year period (2010–2024) using the latest data from the Handbook of Energy and Economic Statistics of Indonesia (HEESI) [3], [4]. By utilizing a quantitative-

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

analytical approach, this study directly benchmarks actual performance against the quantitative targets of the KEN 2025.

The novelty of this study lies in its integrated evaluation of Indonesia's energy-economic trajectory through 2024, utilizing a multi-dimensional framework of energy intensity, elasticity, and Tapio decoupling to expose a significant indicator divergence—a phenomenon where relative elasticity compliance masks an absolute failure in meeting national intensity targets following the 2022 recovery shock. Ultimately, the objective is to determine if the recent return to target compliance in 2024, characterized by an elasticity of 0.90, is sufficient to bridge the 16.5% inefficiency gap created during the recovery years. Thus, this study provides a vital reality check for policymakers, offering an empirical foundation to refine national energy management strategies as the 2025 deadline approaches.

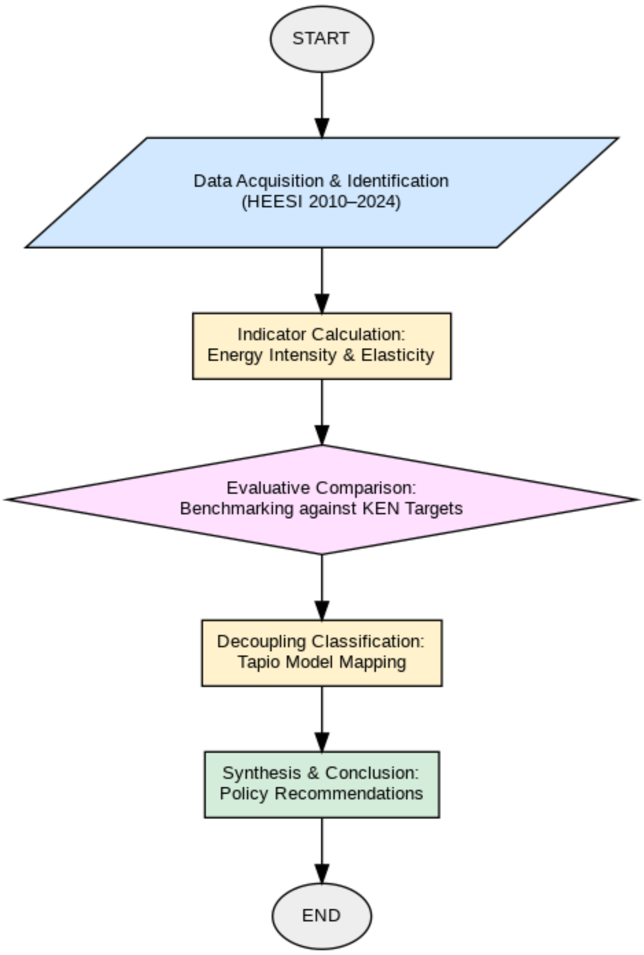

Fig 1. Research Methodology Flowchart

II. METHODOLOGY

A. RESEARCH STAGES

The research follows a systematic five-stage process to ensure data integrity and analytical depth. These stages are visualized in the research flowchart shown in Fig 1.

1) *Data Acquisition and Identification*
Longitudinal secondary data was extracted from the Handbook of Energy and Economic Statistics of Indonesia (HEESI) for the 2010–2024 period. The primary variables identified were Final Energy Consumption (FEC) in Thousand BOE and Gross Domestic Product (GDP) at 2010 constant prices in Trillion Rupiahs.

2) *Indicator Calculation*
Two primary efficiency metrics were calculated annually: Energy Intensity (BOE/Billion Rupiahs) and Energy Elasticity (e). These calculations provided the quantitative basis for measuring how energy demand reacts to economic expansion.

3) *Evaluative Comparison*
The results were benchmarked against the National Energy Policy (KEN) mandates. Specifically, Energy Intensity was measured against the 1% annual reduction target, and Energy Elasticity was evaluated against the $e < 1.0$ threshold to determine policy compliance.

4) *Decoupling Classification*
Using the Tapio Model, each year was categorized into specific decoupling states.

5) *Synthesis and Conclusion*
The final stage involved synthesizing quantitative data with existing literature to identify structural inefficiency gaps and formulating strategic policy recommendations to realign with 2025 targets.

B. MATHEMATICAL EQUATIONS AND INDICATORS

1) *Energy Intensity (I)*
Energy intensity is the total amount of energy consumption per unit of Gross Domestic Product (GDP) [2]. Energy intensity is utilized to describe the level of energy efficiency. It is inversely proportional to energy efficiency; specifically, the less energy required to produce a single unit of output, the more efficient the energy usage becomes [6]. When energy consumption grows more slowly than GDP, energy intensity declines, indicating an improvement [10]. Energy intensity is mathematically expressed by the following equation [11].

$$I_t = \frac{E_t}{Y_t} \quad (1)$$

Where:

I_t = Energy intensity at year t (BOE/Billion Rupiahs)

E_t = Final energy consumption at year t (Thousand BOE)

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Y_t = GDP at 2010 constant prices at year *t* (Trillion Rupiahs)

2) *Energy Elasticity (e)*
Energy elasticity measures the responsiveness of energy consumption to changes in economic growth. It is defined as the ratio of the growth rate of energy consumption to the growth rate of GDP [2]. Energy elasticity is mathematically expressed by the following equation [12].

$$e = \frac{\Delta E/E}{\Delta Y/Y} \quad (2)$$

Where:

e = Energy elasticity coefficient

ΔE = Change in final energy consumption (Thousand BOE)

E = Final energy consumption in the previous year (Thousand BOE)

ΔY = Change in GDP at 2010 constant prices (Trillion Rupiahs)

Y = GDP at 2010 constant prices in the previous year (Trillion Rupiahs)

C. Data Analysis Method

The analysis employs a quantitative-analytical approach, benchmarking empirical results against the strategic targets established by the Indonesian National Energy Policy (Kebijakan Energi Nasional/KEN). Specifically, this study evaluates the alignment of Indonesia's energy trajectory with two primary KEN mandates.

- Energy Intensity Target: Achieving a consistent 1% annual reduction in final energy intensity through the year 2025 [2].
- Energy Elasticity Target: Reaching an energy elasticity coefficient of less than 1 ($e < 1$) by 2025 [2].

To provide a granular assessment of the energy-economic relationship, the results are further classified into decoupling categories. Decoupling occurs when the growth rate of environmental pressure (energy consumption) is lower than the growth rate of economic driving forces (GDP) [13]. Tbl 1 shows eight possibilities of decoupling situations based on Tapio's decoupling terminology [8], [13].

Tapio decoupling model offers distinct analytical advantages over alternative methodologies such as the OECD Decoupling Index. Unlike the OECD index, which is often criticized for its sensitivity to base-year selection, the Tapio model is constructed based on decoupling elasticity, providing a more stable and accurate reflection of dynamic changes in energy intensity by utilizing percentage changes and effectively avoiding the base-year bias that can distort long-term trend analysis [14]. Furthermore, the Tapio framework provides a granular classification of eight logical decoupling states, which is essential for accurately categorizing phenomena such as the 2022 recovery shock and distinguishing between temporary rebounds and structural shifts in Indonesia's energy consumption trajectory. By adopting this mathematically rigorous approach, the study ensures that the identification of the inefficiency gap is grounded in a robust methodology widely accepted in contemporary energy economics [14].

Tbl. 1. Decoupling Classification States Based on the Tapio Model

Decoupling Classification Standards		ΔE	ΔY	e
Decoupling	Weak decoupling	> 0	> 0	$0 < e < 0.8$
	Strong decoupling	< 0	> 0	$e < 0$
	Recessive decoupling	< 0	< 0	$e > 1.2$
Negative decoupling	Expansive negative decoupling	> 0	> 0	$e > 1.2$
	Strong negative decoupling	> 0	< 0	$e < 0$
	Weak negative decoupling	< 0	< 0	$0 < e < 0.8$
Coupling	Expansive coupling	> 0	> 0	$0.8 < e < 1.2$
	Recessive coupling	< 0	< 0	$0.8 < e < 1.2$

The analysis is conducted on an annualized basis to capture the year-on-year volatility of energy consumption relative to GDP and to evaluate the energy-economic decoupling status over time. By

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

benchmarking these results against KEN targets, the study quantifies the inefficiency gap and identifies shifts in decoupling dynamics, providing a statistically grounded assessment of policy compliance and the structural barriers to sustainable growth.

D. Data Validation Method

To ensure the statistical rigor of the analysis and to move beyond a purely descriptive approach, this study employs the Paired Sample T-Test as a validation tool. This method is utilized to determine whether there is a statistically significant difference between the actual energy intensity observed and the National Energy Policy (KEN) target trajectory over the study period (2010–2024).

The Paired Sample T-Test is appropriate for this research as it compares two sets of related observations—the real-world performance versus the policy mandate—within the same time interval [15]. The statistical significance is evaluated based on the following hypotheses:

- Null Hypothesis (H_0): There is no significant difference between the actual energy intensity and the KEN target trajectory ($\mu_1 = \mu_2$).
- Alternative Hypothesis (H_1): There is a significant difference between the actual energy intensity and the KEN target trajectory ($\mu_1 \neq \mu_2$).

The test calculates the t-statistic using the formula:

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} \quad (3)$$

Where:

$\bar{d}$ = the mean of the differences between the paired observations

s_d = is the standard deviation of the differences

n = the number of pairs (years)

The significance is determined by the p-value. A p-value of less than 0.05 indicates that the inefficiency gap identified in this study is statistically significant, providing empirical evidence that the deviation from policy targets is not due to random fluctuation but represents a structural divergence in Indonesia's energy-economic decoupling performance.

III. Results and Discussion

A. Analysis of Energy Intensity and KEN Targets

Energy intensity is a critical metric for evaluating national energy efficiency, representing the amount of energy required to produce one unit of economic output, which refers to (1). According to the historical data from 2010 to 2024, Indonesia's energy intensity has undergone significant fluctuations, characterized by an initial period of improvement followed by a substantial post-pandemic deviation.

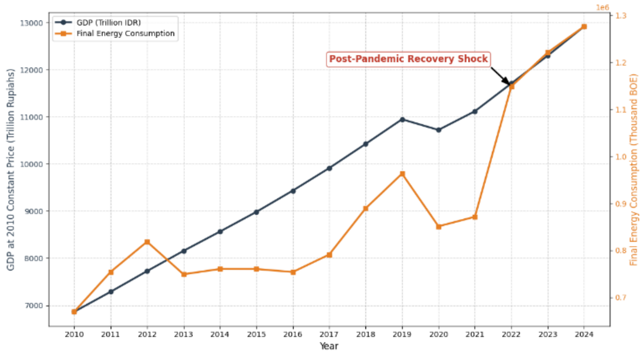

Fig 2. Comparison of GDP Growth vs. Final Energy Consumption (2010–2024)

1) *Historical Efficiency Trends (2010–2021)*
From 2010 to 2021, Indonesia generally followed a declining trend in energy intensity, reaching its lowest point of 78.37 BOE/Billion Rupiahs in 2021. During this decade, economic growth—measured by GDP at 2010 constant prices—maintained a relatively steady upward trajectory, while final energy consumption grew at a more moderate pace. As shown in Fig 2, the gap between GDP and energy consumption remained relatively stable until 2019, indicating a period where efficiency gains were largely aligned with the objectives of the National Energy Policy (KEN).

2) *The Post-Pandemic Recovery Shock (2022)*
This positive trend was abruptly reversed in 2022. Following a brief contraction in both GDP and energy use during the 2020 pandemic year, the economic recovery triggered a significant spike in energy demand where final energy consumption surged to 1,148,486 Thousand BOE—a substantial 31.79% increase from the previous year—while GDP grew by a comparatively modest 5.31%. This divergence is explicitly identified in Fig. 2 as the "Post-Pandemic Recovery Shock", a term conceptualized in this study as a structural anomaly where rapid economic normalization triggers a disproportionate surge in energy demand that outpaces output growth, thereby disrupting long-term efficiency trajectories [16].

Analytically, this shock can be interpreted as a result of the rapid normalization of energy-intensive sectors, particularly manufacturing and heavy industry, which had been suppressed during the 2020–2021 period. As industrial output surged to meet pent-up demand, the lack of immediate efficiency upgrades in aging infrastructure likely led to a disproportionate increase in energy inputs. Furthermore, the total removal of mobility restrictions triggered a surge in the transport

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

sector, which in Indonesia remains heavily reliant on fossil fuel consumption. The combined consequence of these structural drivers was a sharp rise in energy intensity to 98.08 BOE/Billion Rupiahs in 2022, effectively offsetting a decade of cumulative efficiency progress in a single year.

3) *The Inefficiency Gap and KEN Compliance*

Fig 3 presents the results of energy intensity calculations from 2010 to 2024 based on (1), highlighting the growing disparity between actual energy intensity and the KEN target. This mandated target path required energy intensity to reach approximately 84.77 BOE/Billion Rupiahs by 2024. However, the actual intensity recorded in 2024 was 98.76 BOE/Billion Rupiahs—a marginal reduction from the 2023 peak of 99.24, but still significantly higher than the policy requirement.

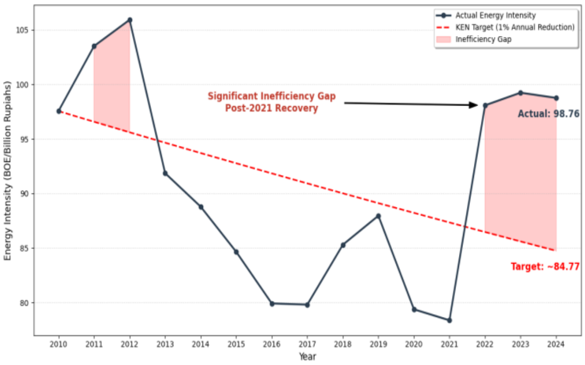

Fig 3. Energy Intensity Gap: Actual vs. KEN Target (2010-2024)

The shaded area in Fig 3, labeled the "Inefficiency Gap," underscores the magnitude of the policy failure following the 2021 recovery. As of 2024, the actual energy intensity is roughly 16.5% higher than the KEN target trajectory. This substantial gap suggests that current industrial and economic recovery models remain heavily dependent on high energy inputs, failing to decouple economic growth from energy consumption as required by national strategic goals.

4) *Statistical Validation: Comparative Analysis of Actual Energy Intensity and KEN Targets*

To enhance the scientific rigor of the study and provide analytical depth beyond descriptive observations, a Paired Sample T-Test was conducted. This statistical procedure evaluates whether the observed discrepancy between Indonesia's actual energy intensity and the National Energy Policy (KEN) target trajectory during the 2010–2024 period is statistically significant.

The results of the statistical validation based on (3) are summarized in Tbl 2 below:

Tbl 1. Paired Samples T-Test Results (Actual Intensity vs. KEN Target)

Measurement Pair	Actual Intensity – KEN Target
Mean Difference	5.094
Std. Deviation	4.887
t-statistic	4.037
p-value (2-tailed)	0.0012

The statistical findings provide several critical insights into Indonesia's energy efficiency performance:

- Statistical significance: The analysis reveals a highly significant difference between actual energy performance and policy mandates ($t(14) = 4.037$, $p = 0.0012$). Since the *p-value* is substantially lower than the standard alpha level of 0.05, the null hypothesis (H_0) is rejected. This confirms that the deviation from the national target is not a result of random annual fluctuations but indicates a systemic failure to align with the mandated 1% annual reduction trajectory.
- Validation of the inefficiency gap: The mean difference of 5.094 intensity points demonstrates a persistent and widening gap between real-world data and policy goals. This statistically validates the existence of the inefficiency gap, which reached a peak of 16.5% in 2024, as a robust finding rather than a mere descriptive observation.
- Severity of the recovery shock: The high t-statistic reflects the significant pressure placed on the national energy system during the post-pandemic era. The sharp surge in intensity recorded in 2022 (98.08) and its relative persistence through 2024 (98.76) has moved the nation's energy profile statistically further away from the KEN target of 84.77 BOE/Billion Rupiahs.
- Policy implications: The rejection of the null hypothesis provides empirical evidence that current decoupling strategies and energy efficiency measures are statistically insufficient to mitigate the observed indicator divergence. These results underscore a critical requirement for targeted structural interventions, specifically through mandatory energy efficiency audits in high-intensity industrial sub-sectors and the implementation of fuel-switching mandates in the transport sector. Transitioning from aggregate elasticity monitoring toward these sector-specific measures is essential to align the

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

national growth trajectory with the absolute intensity reduction targets mandated by the KEN 2025.

B. ANALYSIS OF ENERGY ELASTICITY AND KEN TARGETS

Energy elasticity (*e*) serves as a critical indicator of the relationship between energy consumption growth and economic expansion. To ensure sustainable development, the National Energy Policy (KEN) stipulates a strategic target for Indonesia to maintain an energy elasticity coefficient of less than 1.0 by 2025. An elasticity value below this threshold indicates that economic growth is being achieved with increasingly efficient energy use.

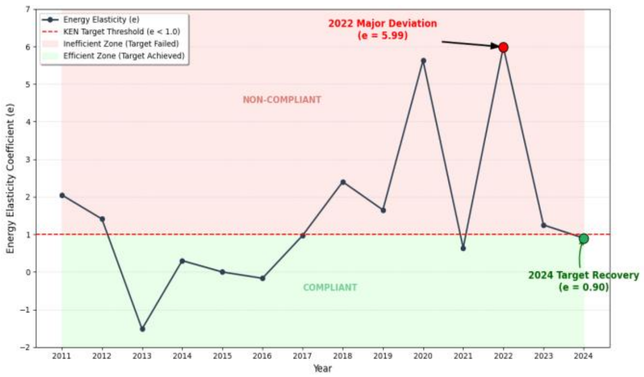

Fig 4. Indonesia Energy Elasticity Trend (2010-2024)

1) *Fluctuating Compliance and Pre-Pandemic Trends (2011–2019)*

The historical performance of Indonesia's energy elasticity shows a highly volatile trend with inconsistent compliance with KEN targets, as shown in Fig 4. Between 2011 and 2017, Indonesia largely operated within the "Compliant" zone, characterized by elasticity values below 1.0. Notable performance was observed in 2013 and 2016, where elasticity dropped into negative territory, reaching -1.52 and -0.17, respectively. These figures suggest periods of strong decoupling, where the economy grew even as total energy consumption decreased. However, this trend shifted toward a "Non-Compliant" status in 2018 and 2019, as elasticity rose to 2.40 and 1.65, indicating a return to energy-intensive economic growth.

2) *The 2022 Post-Pandemic Shock*

The most significant disruption to Indonesia's energy efficiency goals occurred during the post-pandemic recovery. While 2021 saw a temporary return to target compliance (*e* = 0.64), 2022 recorded a major deviation with the elasticity coefficient surging to 5.99. As illustrated in the "Major Deviation" callout in Fig 4, this surge represents the highest level of energy inefficiency in the observed period. This extreme value implies that for every 1% of GDP growth, energy consumption expanded by nearly 6%, signaling a severe structural dependency on high energy inputs to jumpstart economic activity after the COVID-19 lockdowns.

3) *Recovery toward 2025 Targets (2023–2024)*

Following the peak in 2022, the trend began to stabilize. Although 2023 remained slightly above the threshold at 1.25, the data for 2024 shows a significant target recovery with the elasticity coefficient falling to 0.90. This return to the "Compliant" zone (green shaded area in Fig 4) is a positive signal for Indonesia's 2025 policy goals. Nevertheless, because the 2024 value is very close to the 1.0 limit, the current energy-economic balance remains precarious. Sustained efforts in energy conservation and industrial efficiency are mandatory to ensure that this recovery translates into a long-term trend rather than a temporary fluctuation.

C. DECOUPLING ANALYSIS BASED ON TAPIO MODEL

The relationship between economic growth and energy consumption in Indonesia is further examined through the Tapio decoupling model, which categorizes energy-economic development into eight distinct states based on the elasticity of energy consumption (*e*). By mapping the annual growth of GDP against the growth of final energy consumption, this study provides a granular view of Indonesia's progress toward decoupling.

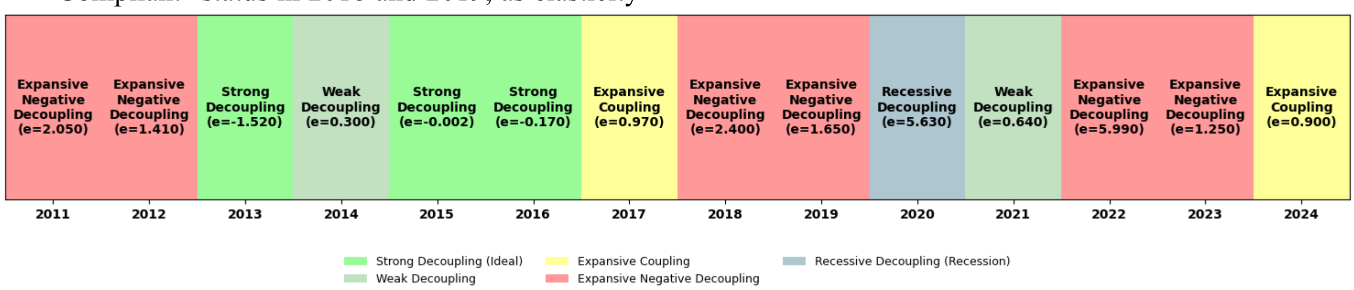

Fig 5. Timeline of Indonesia's Decoupling Status (2011–2024)

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

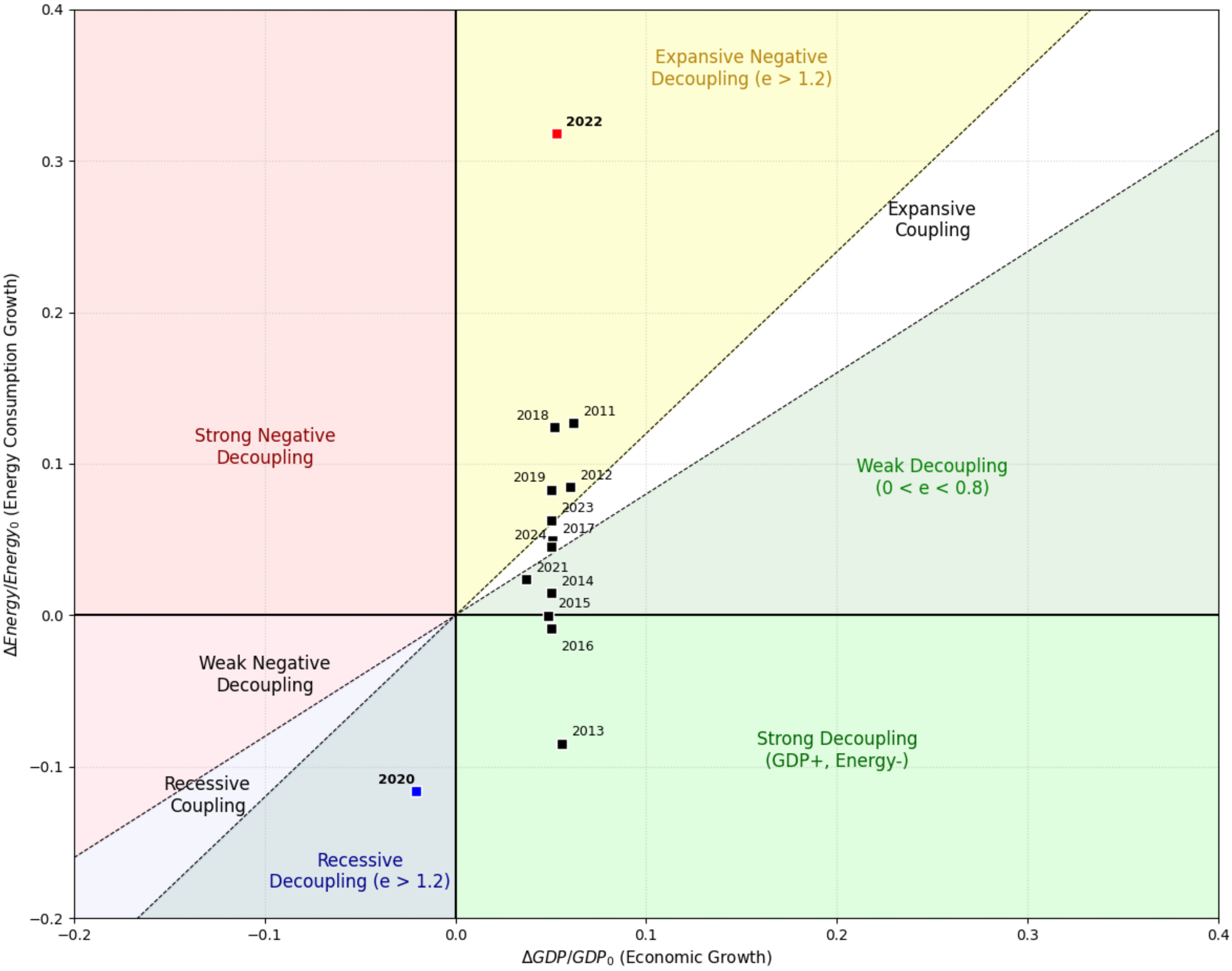

Fig 6. Tapio Decoupling Analysis of Indonesia Energy-Economic Growth (2011-2024)

1) *Evolution of Decoupling Status (2011–2019)*
Fig 5 shows that between 2011 and 2019, Indonesia experienced a non-linear decoupling trajectory, alternating between periods of efficiency and intensive energy use.

- *Expansionary Phases*: The early decade was marked by expansive negative decoupling (2011–2012), where energy consumption grew much faster than the economy ($e > 1.2$). This returned later in the decade (2018–2019) with elasticity values of 2.40 and 1.65, respectively.
- *Peak Efficiency*: Significant progress was achieved between 2013 and 2016. During this period, Indonesia reached strong decoupling status (2013, 2015, and 2016), a highly desirable state where the economy continues to expand while total energy consumption decreases. As shown in Fig 6, these years are positioned in the lower-right quadrant, representing the pinnacle of energy-economic efficiency in the observed timeline.

2) *Pandemic and the Recovery Shock (2020–2022)*
The global health crisis and subsequent recovery introduced severe anomalies into Indonesia's decoupling trend.

- *The 2020 Recession*: The year 2020 is classified as recessive decoupling. During this year, both GDP and energy consumption contracted; however, the sharp drop in energy use resulted in an elasticity of 5.63, indicating that the energy sector was more volatile than the overall economy during the lockdowns.
- *The 2022 Shock*: As economic activity resumed, Indonesia suffered a significant post-pandemic recovery shock. The status shifted back to expansive negative decoupling with a record-high elasticity of 5.99. Fig 6 highlights 2022 as a major outlier, positioned deep within the yellow inefficient zone, indicating a critical failure in maintaining energy efficiency during the growth jump.

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

3) Current Status and 2025 Outlook (2023–2024)

By 2024, the decoupling status moved into expansive coupling (e = 0.90). While this indicates a return to the targeted compliance zone (e < 1.0), it represents a state of "coupling" rather than "decoupling". The economy is currently growing in almost direct proportion to energy inputs. To achieve the 2025 National Energy Policy (KEN) goals, Indonesia must transition from this state of coupling back toward weak decoupling or strong decoupling, ensuring that future economic expansion requires progressively fewer energy resources.

D. DISCUSSION

The findings presented in the preceding sections reveal a critical shift in Indonesia's energy-economic trajectory, characterized by a return to high energy intensity and expansive negative decoupling post-2021. This section contextualizes these results by comparing them with existing literature.

1) Divergence from Pre-Pandemic Efficiency Gains

The findings reveal a critical shift in Indonesia's energy-economic trajectory, characterized by a return to high energy intensity and expansive negative decoupling post-2021. Prior to this period, Ilhaq & Syafitri [5] observed that Indonesia's energy elasticity was generally manageable, though they warned of the structural fragility in existing efficiency policies. Our results confirm this fragility; the 2022 elasticity spike to 5.99 far exceeded the historical fluctuations noted in their study, suggesting that the fragility they identified has now manifested as a full-scale structural reversal. This alignment is further supported by the work of Mukaromah & Widodo [7], who highlighted that while Indonesia had shown periods of weak decoupling, the industrial sector remained heavily reliant on fossil fuels. The 16.5% inefficiency gap identified in 2024 validates their concerns, indicating that the structural fossil-fuel dependency has not only persisted but intensified during the recovery phase, preventing the actual intensity from converging with the KEN target.

2) Post-Pandemic Shock and Global Comparison

Chen et al. [8] utilized the Tapio model to analyze global decoupling trends and noted that developing economies often face recovery shocks where energy consumption rebounds faster than GDP. Our data for 2022 serves as a textbook example of this phenomenon, transitioning from weak decoupling in 2021 to expansive negative decoupling in 2022—a shift that Chen et al. argue is common in nations lacking aggressive green stimulus packages.

Pratiwi [6] examined Indonesia's energy intensity and predicted that without significant intervention, the KEN 2025 targets would be missed. Our 2024 data (Intensity = 98.76 BOE/Billion Rupiahs) validates Pratiwi's concerns, showing a stagnant reduction rate that fails to close the gap created by the 2022 shock.

3) The 2024 Policy-Indicator Contradiction (Indicator Divergence)

A central contribution of this study is the interpretation of the divergence observed in 2024, where Indonesia achieved compliance with the National Energy Policy (KEN) elasticity threshold yet remained in a state of expansive coupling under the Tapio framework. This contradiction—conceptualized in this study as a significant indicator divergence—reveals the limitations of relying on a single indicator like elasticity to measure policy success. While the return to elasticity compliance suggests that the growth rate of energy consumption is stabilizing relative to GDP, the Tapio model reveals that the absolute relationship remains fundamentally coupled.

This finding challenges conventional policy benchmarking by demonstrating an indicator divergence, wherein a compliant elasticity coefficient may signal a false positive 'success' while absolute energy intensity continues to indicate a performance 'failure' relative to national mandate. This discrepancy suggests that Indonesia's current recovery is driven by a stabilization of demand rather than a fundamental technological shift or fuel-switching in the industrial and transport sectors. As demonstrated by the 16.5% gap, marginal improvements in elasticity are insufficient to offset a decade of high-intensity industrial habits. Therefore, this study extends the existing literature by arguing for a multi-criteria policy framework that prioritizes absolute intensity reduction over relative growth ratios to ensure a true transition toward a decoupled energy-economy trajectory.

IV. CONCLUSION

This research evaluates Indonesia's energy-economic decoupling trajectory from 2010 to 2024 by integrating energy intensity, elasticity, and Tapio classification frameworks. The results demonstrate that while Indonesia achieved strong decoupling and met National Energy Policy (KEN) mandates in the mid-2010s, this progress was abruptly reversed by a structural divergence during the 2022 recovery phase. This period, identified as a recovery shock, was characterized by an expansive negative decoupling status and a record-high energy elasticity of 5.99,

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

signifying an energy-intensive economic reactivation that outpaced efficiency gains.

The empirical findings are further validated by a Paired Sample T-Test, which confirms a statistically significant discrepancy between actual energy intensity and the prescribed KEN targets ($p < 0.05$). The rejection of the null hypothesis provides robust evidence that Indonesia's current efficiency measures are statistically insufficient to align with national strategic objectives. Crucially, the 2024 data reveals a significant indicator divergence; although Indonesia returned to relative elasticity compliance with a coefficient of 0.90, the absolute energy intensity remains 16.5% above the prescribed KEN trajectory. This persistent inefficiency gap confirms that Indonesia's economic expansion remains fundamentally coupled with energy consumption, posing a critical challenge to the 2025 mandates. To bridge this gap, policy interventions must shift from aggregate growth-ratio monitoring toward targeted structural measures, such as mandatory energy efficiency audits in the industrial sector and the acceleration of electrification and fuel-switching in transport.

For further development, it is suggested that future research employ sectoral decomposition analysis to pinpoint the specific sub-sectors driving the post-pandemic inefficiency. Additionally, subsequent studies should investigate the impact of carbon pricing mechanisms and renewable energy integration on accelerating the transition from expansive coupling back to strong decoupling, ensuring Indonesia's long-term energy security and alignment with global climate commitments.

REFERENCES

[1] Indonesia, *Peraturan Presiden Nomor 22 Tahun 2017 Tentang Rencana Umum Energi Nasional*. Indonesia, 2017. [Online]. Available: https://peraturan.go.id/id/perpres-no-22-tahun-2017

[2] Pemerintah Republik Indonesia, *Peraturan Pemerintah Republik Indonesia Nomor 79 Tahun 2014 Tentang Kebijakan Energi Nasional*. Indonesia, 2014. [Online]. Available: https://peraturan.go.id/eng/pp-no-79-tahun-2014

[3] Ministry of Energy and Mineral Resources, "Handbook of Energy and Economic Statistics of Indonesia 2020," Jakarta, 2021. [Online]. Available: https://www.esdm.go.id/en/publication/handbook-of-energy-economic-statistics-of-indonesia-heesi

[4] Ministry of Energy and Mineral Resources, "Handbook of Energy and Economic Statistics of Indonesia 2024," Jakarta, 2025. [Online]. Available: https://www.esdm.go.id/en/publication/handbook-of-energy-economic-statistics-of-indonesia-heesi

[5] M. S. Ilhaq and W. Syafitri, "Analisis Determinan Intensitas Energi di Indonesia," *Journal of Development Economic and Social Studies*, vol. 1, no. 4, pp. 561–573, 2022, doi: 10.21776/jdess.2022.01.4.06.

[6] D. R. Pratiwi, "Analisis Determinan Intensitas Energi Di Indonesia Tahun 2000-2020," *Jurnal Budget: Isu dan Masalah Keuangan Negara*, vol. 7, no. 1, pp. 96–113, 2022, doi: 10.22212/jbudget.v7i1.

[7] K. Mukaromah and W. Widodo, "Analisis Decoupling Konsumsi Listrik dan Determinan Emisi Karbon: Studi Kasus Negara ASEAN," *Diponegoro Journal of Economics*, vol. 10, no. 3, pp. 119–134, 2021, doi: 10.14710/djoe.31887.

[8] C. Chen, M. N. Inamdar, and A. Al-Odaini, "Decoupling carbon emissions from power sector growth in Indonesia," *Discover Environment*, vol. 3, no. 1, 2025, doi: 10.1007/s44274-025-00426-0.

[9] H. Allcott and M. Greenstone, "Is There an Energy Efficiency Gap?," *Journal of Economic Perspectives*, vol. 26, no. 1, pp. 3–28, 2012, doi: 10.1257/jep.26.1.3.

[10] International Energy Agency, "Energy Efficiency 2025," 2025. [Online]. Available: https://www.iea.org/reports/energy-efficiency-2025

[11] F. Kartiasih, Y. Syaukat, and L. Anggraeni, "Determinan Intensitas Energi di Indonesia," *Jurnal Ekonomi dan Pembangunan Indonesia*, vol. 12, no. 2, pp. 192–214, 2012, doi: 10.7454/jepi.v12i2.1350.

[12] L. G. Brookes, "More on the Output Elasticity of Energy Consumption," *J. Ind. Econ.*, vol. 21, no. 1, pp. 83–92, 1972, doi: 10.2307/2098109.

[13] X. Y. Zeng and W. M. Wong, "Decoupling of Environmental Pressures From Economic Activities: Evidence From Taiwan," *Global Journal of Business Research*, vol. 8, no. 4, pp. 41–50, 2014, [Online]. Available: https://access.portico.org/stable?au=phx4jw3gq4p

[14] L. Yuan *et al.*, "Decoupling of economic growth and resources-environmental pressure in the Yangtze River Economic Belt, China," *Ecol. Indic.*, vol. 153, no. July 2022, p. 110399, 2023, doi: 10.1016/j.ecolind.2023.110399.

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

[15] T. K. Kim, "T test as a parametric statistic," *Korean J. Anesthesiol.*, vol. 68, no. 6, pp. 540–546, 2015, [Online]. Available: https://synapse.koreamed.org/articles/1156170
[16] K. O. Ogbeta, A. Faruk, and F. O. Omotosho, "COVID-19 Shocks and Post Pandemic Recovery in The Gambia," *Covenant Journal of Business & Social Sciences (CJBSS)*, vol. 14, no. 1, pp. 51–65, 2023, [Online]. Available: https://journals.covenantuniversity.edu.ng/index.php/cjbss/article/view/3975

AUTHORS BIOGRAPHY AND CONTRIBUTIONS

Amirul Mahmud was born in Pemalang. He holds a Bachelor's degree from Semarang State University (UNNES) and is currently pursuing a Master of Electrical Engineering at the Christian University of Indonesia (UKI). Professionally, he works as a civil servant at the National Public Procurement Agency (LKPP). His primary research concentrations include renewable energy and energy policy analysis.

© the Authors (2026)
This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.