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GREEN TRANSITION, UNEQUAL BURDENS: GENDER INEQUALITY AND THE JUSTICE GAP IN ASEAN

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Abstract
The green transition is expected to reduce environmental burdens and widen social justice, yet these gains do not necessarily advance together. This study examines whether renewable-energy progress across ASEAN has been accompanied by comparable improvements in environmental conditions and gender equality. Using a comparative longitudinal design, country-level data from Our World in Data for 2016–2023 were analyzed in Python through Sen's slope estimation, standardized directional trends, and cross-country trajectory mapping. The results reveal an asynchronous green transition, in which energy, environmental, and gender trajectories move at substantially different speeds. Malaysia demonstrates the most relatively aligned trajectory, whereas Cambodia, Indonesia, Laos, and Thailand record renewable-energy progress without comparable improvements in PM2.5 exposure. Gender inequality improves across the observed countries, but its pace varies considerably and does not consistently correspond with either renewable-energy growth or environmental improvement. These findings challenge the assumption that technological progress naturally translates into broader justice outcomes. This study conceptualizes such divergence as the green transition–justice gap: the distance between progress in energy transformation and its translation into environmental and gender-justice outcomes. The findings reposition law and institutions as critical mechanisms for connecting technological change with the distribution of environmental and social benefits. For ASEAN, the quality of green transition should therefore be judged not only by how rapidly energy systems become greener, but by how consistently that progress reduces environmental burdens and advances social justice.

Keywords: Energy Justice; Environmental Justice; Gender Inequality; Green Transition; Just Transition.

INTRODUCTION

The green transition brings with it a paradox that is increasingly difficult to ignore: a country can become greener without necessarily becoming more just. The increase in renewable energy indicates important changes in energy production systems, but does not in itself indicate that the environmental burden that society receives has been reduced or that the benefits of the transition are more evenly distributed. The just transition literature has therefore shifted the measure of transition success from mere technical achievements to issues of distribution of benefits, risks, recognition, and participation in the process of change [1];[234]. This shift is important because the development of renewable energy alone can generate new configurations of injustices when technological change takes place without a

[1] (Wang & Lo, 2021
[2] Nationńska et al., 2021;
[3] van Bommel & Höffken, 2021 ;
[4] Wood et al., 2024)

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commensurate transformation of social and environmental conditions [5] ; [6]. Thus, the crucial question in the green transition is no longer just how quickly the energy system changes, but whether it also goes hand in hand with a reduced environmental burden and improved social justice.

Gender makes this issue more complex because society does not enter the green transition from an equal social position. Differences in access to employment, education, economic resources, political representation, and decision-making shape different capacities to benefit and face the risks of economic and environmental change. Recent studies have shown that gender relations and the energy transition have evolved from women's representation issues to more structural issues of access, vulnerability, employment, participation, and distribution of transition benefits [7]; [8]. The feminist perspective even reminds that the addition of women to the energy sector does not in itself change the structures that generate inequality [9]. Therefore, gender-just transition demands attention not only to the presence of women, but to the social conditions that determine who has the resources, voice, and capacity to benefit from that transformation[10]. Gender justice in the energy transition is thus related to access, distribution of benefits, participation in decision-making, and recognition of different social positions [11]. This issue is particularly relevant for Asia, where gender inequality is still related to different energy transition and environmental sustainability pathways between countries [12]. At the ASEAN job market level, green job creation also brings with it the issue of who gets new jobs and who bears the cost of changing the job structure[13]. In the context of ASEAN itself, obstacles to women's participation in the energy transition are still found at the institutional and structural levels [14].

ASEAN is an important space to test these issues because countries in one region face the same decarbonization demands, but move from different energy structures, economic capacity, environmental conditions, and social inequalities. Another study puts the issue at hand in ASEAN's environmental policy capacity to achieve sustainable development goals

[5] (Urkidi Azkarraga & Gurrutxaga, 2024
[6] Tunn et al., 2024)
[7] (Cellini et al., 2025
[8] Calidori et al., 2024)
[9] Martina Angela Caretta and Vela-Almeida Diana, "Just Energy Transition and Gender. A Systematic Review for Feminist Research," *Energy Research & Social Science*, 2025, https://doi.org/https://doi.org/10.1016/j.erss.2025.104138.
[10] Paula Walk, "From Parity to Degrowth: Unpacking Narratives of a Gender-Just Transition," *Energy Research & Social Science* 112 (2024): 103513, https://doi.org/10.1016/j.erss.2024.103513.
[11] Raghu Raman et al., *Energy Justice and Gender : Bridging Equity , Access , and Policy for Sustainable Development* (Springer International Publishing, 2025).
[12] Sevda Kuşkaya et al., "Spatial Spillover Effects of Gender Inequality on the Path to Energy Transition and Environmental Sustainability in Asia," *Utilities Policy* 95, no. 101935 (2025).
[13] Samantha A Sharpe and Cristina M Martinez-Fernandez, "The Implications of Green Employment: Making a Just Transition in ASEAN," *Sustainability* 13, no. 13 (2021): 7389, https://doi.org/10.3390/su13137389.
[14] Theresia B Sumarno et al., "Challenges in Increasing Women ' s Participation in the Energy Transition in ASEAN and G7 Countries : A Qualitative Approach Based on the Three Tenets of Justice," *Energy Policy* 191, no. September 2023 (2024): 114163, https://doi.org/10.1016/j.enpol.2024.114163.

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[15], the policy dilemma towards carbon neutrality [16], as well as the need for the integration of power systems and cross-border transmission to accelerate the decarbonization of the electricity sector [17]. [18] further showing that the sustainability of the energy transition path also differs between Southeast Asian countries. Other studies have shown that transitions that are formally geared towards decarbonization can still maintain or even shift the socio-ecological burden to certain groups and regions [1920]. The literature has provided a solid basis for understanding whether the transition is taking place, how it is financed, and whether the principle of fairness has been incorporated into policy. However, more limited attention is paid to a different question: are energy system advancements, reduced environmental burdens, and improved gender equality really moving together over time? This gap is important because a country can show progress on one dimension while another dimension is moving slower or even stagnant.

This study fills this gap by introducing asynchronous green transition as a framework to read the misalignment between energy transition progress, changes in environmental burdens, and changes in gender inequality in ASEAN countries that have comparable data. Different from approaches that assess transition success through a single indicator or assume a direct causal relationship between renewable energy and gender equality, this study views all three as development dimensions that can move at different speeds. Longitudinal data from Our World in Data were used to bring together the share of electricity production from renewables, PM2.5 exposure from human activities, and the Gender Inequality Index, while the level of economic development was used as a controlling context. Python-assisted comparative analysis is then used to identify patterns of change and possible green transition–justice gaps, i.e. situations when energy system progress does not go hand in hand with improving environmental conditions and gender equality. Thus, the contribution of this research is not simply to add gender to the ASEAN energy transition debate, but rather to shift the question from "how green a country has become" to "whether its ecological and social progress is moving together.

LITERATURE REVIEW

Green transition extends beyond the technological shift from fossil fuels to low-carbon energy; it also reshapes economic structures, governance, employment, and the distribution of benefits and risks. The literature on just transition, energy justice, and environmental

[15] Mark Elder and Gemma Ellis, "ASEAN Countries' Environmental Policies for the Sustainable Development Goals (SDGs)," *Environment, Development and Sustainability* 25 (2023): 10975–93, https://doi.org/10.1007/s10668-022-02514-0.
[16] Fang Yang and Chutong Li, "The Status Quo, Dilemma, and Transformation Path of the Carbon Neutrality-Related Policy of the ASEAN," *Sustainability* 16, no. 3 (2024): 1348, https://doi.org/10.3390/su16031348.
[17] Sheng Zhong et al., "Accelerating ASEAN's Energy Transition in the Power Sector through Cross-Border Transmission and a Net-Zero 2050 View," *IScience* 28, no. 1 (2025): 111547, https://doi.org/10.1016/j.isci.2024.111547.
[18] Derouez & Ifa, (2025)
[19] (South, 2025)
[20] ; Karg et al., 2025)

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justice therefore distinguishes energy progress from justice outcomes, emphasizing that renewable-energy expansion does not necessarily ensure fairer social or environmental conditions [21] This distinction is particularly relevant in ASEAN, where differences in regulatory capacity, investment structures, and carbon lock-in can produce uneven transition pathways across countries [22] . A just transition should therefore be assessed not only by how rapidly energy systems change, but also by how their benefits and burdens are distributed.

Gender adds a structural dimension to this justice question because societies do not enter the transition with equal access to resources, employment, representation, or decision-making power [23]. Feminist scholarship consequently distinguishes women's participation from gender justice: greater representation in green sectors does not necessarily transform the underlying distribution of resources and power [24]. From a socio-legal perspective, law and institutions mediate how technological change is translated into rights, protection, participation, and the distribution of benefits and burdens. Building on this foundation, the green transition–justice gap refers to the asynchrony that arises when progress in energy transition is not accompanied by comparable improvements in environmental conditions and gender justice, providing an analytical lens for assessing whether green transformation is also socially just.

METHOD

This study uses a comparative-longitudinal quantitative approach to analyze the misalignment of energy transition developments, environmental burdens, and gender inequality in ASEAN countries during 2016–2023. Secondary data was obtained from Our World in Data (OWID) with four indicators, namely the share of electricity production from renewables as a representation of the energy transition, human-caused PM2.5 exposure as an environmental burden, the Gender Inequality Index (GII) as a dimension of gender justice, and PPP GDP per capita as a development context. The 2016–2023 period was selected based on the slice of data availability that allowed the three main indicators to be consistently compared between countries, while countries that did not have adequate observations in that

[21] Wang and Lo, "Just Transition: A Conceptual Review"; Iwińska, Lis, and Mączka, "From Framework to Boundary Object? Reviewing Gaps and Critical Trends in Global Energy Justice Research"; Natascha Van Bommel and I H Johanna, "Energy Research & Social Science Energy Justice within , between and beyond European Community Energy Initiatives : A Review" 79, no. June (2021), https://doi.org/10.1016/j.erss.2021.102157; Wood et al., "Energy Research & Social Science Strengthening the Foundations of Energy Justice Scholarship : What Can Philosophy Contribute ?"
[22] Raphael J Heffron et al., "Environmental and Sustainability Indicators Defining a ' Just Energy Investment ' for the ASEAN Just Transition," *Environmental and Sustainability Indicators* 22, no. December 2023 (2025): 100367, https://doi.org/10.1016/j.indic.2024.100367.
[23] Sumarno et al., "Challenges in Increasing Women ' s Participation in the Energy Transition in ASEAN and G7 Countries : A Qualitative Approach Based on the Three Tenets of Justice"; Cellini et al., "Energy Research & Social Science Exploring the Nexus of Gender and Energy Transitions : A Systematic Literature Review"; Caretta and Diana, "Just Energy Transition and Gender. A Systematic Review for Feminist Research."
[24] Walk, "From Parity to Degrowth: Unpacking Narratives of a Gender-Just Transition"; Víctor Martín et al., "Energy Research & Social Science Gender Challenges in Just Energy Transition : The Labour Market Perspective" 127, no. September (2025), https://doi.org/10.1016/j.erss.2025.104303.

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period were not forced into the analysis. The operationalization of indicators, improvement directions, and analytical functions of each variable are presented in Table 1.

Table 1. Operationalizatio n of Variables and Analytical Direction

Dimension	Indicator	Unit	Direction of Improvement	Analytical Role	Analysis Perio	Source File
Energy transition	Renewable electricity share	%	Higher	Main outcome dimension	2016–2023	share-electricity-renewables.filtered(1).zip
Environmental burden	Human-caused PM2.5 exposure	µg/m³	Lower	Main justice dimension	2016–2023	human-caused-air-pollution-exposure.filtered(1).zip
Gender justice	Gender Inequality Index	0–1	Lower	Main justice dimension	2016–2023	gender-inequality-index-from-the-human-development-report.filtered(1)(1).zip
Development context	GDP per capita PPP	constant 202 international-	Contextual (n	Context variable	2016–2023	gdp-per-capita-worldbank.filtered(1).zip

Source: Processed by the author based on the OWID

Data processing is carried out using Python with country-year analysis units and without imputation to unavailable values. The direction of change of each indicator is estimated using Sen's slope so that the comparison emphasizes longitudinal trends rather than differences in values in a given year; the increase in renewables is interpreted as progress in the energy transition, while the decrease in PM2.5 and GII is interpreted as environmental and gender improvement, respectively. The three directions of change are then standardized into z-scores to compare the relative velocity between dimensions and visualized through scatter plots and heatmaps. Based on the combination of the direction of change, the trajectory of the country is then descriptively grouped into aligned green transition, environmentally decoupled transition, and stalled/regressive transition; This classification is used as a comparative tool, not to test causal relationships.

The contents of the study method are data collection techniques, data sources, methods of data analysis, correlation tests, and so on, written in Times New Roman 12 font. This chapter can also include the scientific formula used for data analysis/correlation testing.

RESULTS AND DISCUSSION

Uneven Green Transition and Environmental Burdens across ASEAN

The green transition acquires substantive meaning not when the energy source is solely changing, but when the change is followed by a reduction in the ecological burden that society receives. This premise distinguishes the advancement of energy technology from the socio-ecological outcomes of the transition because the two do not always develop in the same direction and speed. The energy justice literature has shown that low-carbon energy expansion can produce uneven benefits when technological change takes place within economic and institutional structures that still maintain the old risk distribution [25][26][27]. The analysis in this section therefore does not place the growth of renewable electricity as the single measure of success, but rather compares it with changes in PM2.5 exposure due to human activities in ten ASEAN countries during 2016–2023.

The results of the Sen slope estimate show a sharp difference in the speed of change in renewable energy between countries. Cambodia recorded the highest increase of 2.052

[25] (Wang & Lo, 2021;
[26] Nationńska et al., 2021;
[27] Wood et al., 2024)

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percentage points per year, followed by Laos 1.963, Thailand 0.785, Malaysia 0.738, and Indonesia 0.572, while Singapore increased more limited by 0.077 percentage points per year. Brunei and Timor-Leste are relatively stagnant, while the Philippines and Myanmar show a downward trend of −0.405 and −1.745 percentage points per year, respectively. These variations show that the ASEAN energy transition does not take place as a homogeneous regional process, in line with studies that identify differences in carbon lock-in, energy market structure, institutional capacity, and policy reform directions as factors that differentiate the transition journey between ASEAN countries (Aleluia et al., 2022; Vakulchuk et al., 2023).

The difference in speed does not in itself explain the quality of the transition. Comparison with Cent slope PM2.5 actually results in a more complex configuration because countries with high renewable growth do not necessarily experience a decrease in pollution exposure. Malaysia recorded a renewable increase of 0.738 percentage points per year along with a decrease in PM2.5 of 0.114 µg/m³ per year, while Singapore showed a similar direction with a 0.077 increase in renewable and a decrease in PM2.5 of 0.043 µg/m³ per year. Cambodia is in the opposite position: the highest renewable growth in the sample actually took place with a PM2.5 increase of 0.438 µg/m³ per year. This contrast shows that the speed of change in the electricity mix cannot be used directly to conclude the magnitude of the environmental improvement experienced by the population.

The relationship between these trajectories is visualized in Figure 1, with the horizontal axis showing the Sen slope of renewable electricity production and the vertical axis showing the environmental improvement calculated as the opposite of the Sen slope of PM2.5. Positive values on the horizontal axis mean that renewable electricity production increases, while positive values on the vertical axis mean that PM2.5 exposure decreases. The top-right position thus depicts a situation when renewable progress is accompanied by environmental improvement, while the bottom-right shows renewable growth that has not been accompanied by a decrease in PM2.5 exposure. This visualization does not measure causal relationships, but shows whether the two processes have an aligned direction of change during the observation period.

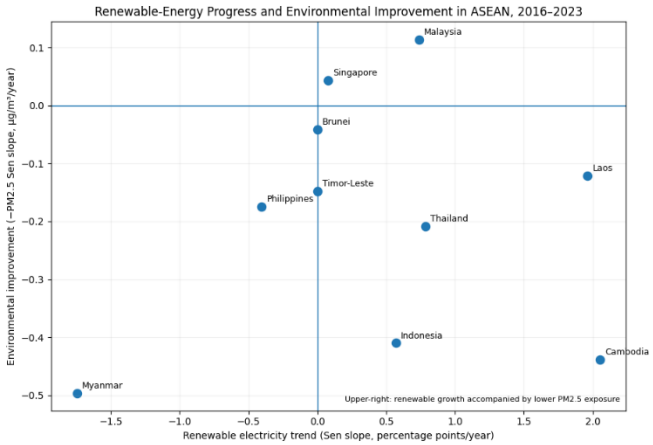

Figure 1. Renewable-Energy Progress and Environmental Improvement in ASEAN, 2016–2023

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Figure 1 shows a fairly clear empirical separation. Malaysia and Singapore are in the upper right quadrant, showing a combination of an increase in renewables and a decrease in PM2.5. Cambodia, Indonesia, Laos, and Thailand are on the right-bottom: renewable electricity production is increasing, but PM2.5 exposure is moving in a worsening direction. Indonesia recorded a renewable increase of 0.572 percentage points per year along with an increase in PM2.5 of 0.410 μg/m³ per year, while Laos showed much faster renewable growth of 1.963 but still accompanied by an increase in PM2.5 of 0.121 μg/m³ per year. This pattern shows that ASEAN's differences are not just between countries that are fast and slow to make transitions, but between progress in energy structures and the ability to turn that progress into a reduction in ecological burden.

The findings of Cambodia and Laos are important because they challenge the linear reading that the greater the growth of renewables, the better the environmental output. These results appear to be different from the ASEAN study that found the contribution of renewable energy consumption to reducing CO_2 emissions and long-term economic development (Mu'min et al., 2024). This difference does not indicate a conflict of evidence because CO_2 and PM2.5 represent two different ecological issues: CO_2 primarily describes pressures on the climate system, while PM2.5 exposure captures air pollution that is closer to the daily lives of residents. Renewable growth can therefore support the decarbonization of the power sector without automatically eliminating pollution from transportation, industry, biomass burning, land use, and other anthropogenic activities.

These differences also clarify the legal and institutional positions in the transition process. Technology changes the way energy is produced, but regulations determine how industries are controlled, externalities are limited, environmental standards are enforced, and protections are distributed to society. The energy justice perspective shows that the benefits of the transition can be separated from the distribution of risks when technological change is not accompanied by adequate governance changes (Iwińska et al., 2021; Heffron et al., 2024). Studies of renewable energy development in other contexts also found that projects labeled green can still maintain the issues of space distribution, participation, and recognition of affected groups (Urkidi Azkarraga & Gurrutxaga, 2024; Tunn et al., 2024). The positions of Cambodia, Indonesia, Laos, and Thailand in Figure 1 thus do not prove the failure of renewable energy, but show that technological transformation and ecological risk reduction are two achievements that must be tested separately.

The cases of Malaysia and Singapore provide a comparison that prevents the opposite conclusion from becoming too deterministic. Both countries show that the increase in renewables and the improvement of PM2.5 can take place in the same direction even though the growth rates of renewables are much different. These findings intersect with studies that place institutional capacity, regulatory design, and investment quality as important elements in determining the output of the ASEAN energy transition (Vakulchuk et al., 2023; Heffron et al., 2024). The comparison also shows that the volume of renewable growth is not the only differentiator because Singapore with a growth of only 0.077 percentage points per year continues to experience a decrease in PM2.5, while Cambodia with a growth of 2.052 points actually experiences an increase in exposure. This variation shifts the analytical question

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from "how much renewables are added" to "in what kind of development structure does the addition take place".

The trajectory of Myanmar and the Philippines reinforces the need for non-linear readings. Myanmar is in the lower left quadrant with a decline in renewables −1.745 percentage points per year and PM2.5 increase of 0.496 mg/m³ per year, so that the decline takes place on both indicators. The Philippines also experienced a decline in renewables of −0.405, but a lower PM2.5 increase of 0.175 mg/m³ per year. Brunei and Timor-Leste are around the renewable zero line with PM2.5 steadily increasing. This diversity supports the argument that the transition path is shaped by different energy dependency paths, development structures, investments, and regulatory capabilities so that the categories "ASEAN" should not erase institutional variation within the area [28][29][30].

Overall, the results of this data processing show three energy–environmental configurations, but do not place them as a final justice typology. Malaysia and Singapore show alignment between renewable growth and PM2.5 improvement; Cambodia, Indonesia, Laos, and Thailand show a separation between renewable progress and environmental outcomes; while Brunei, Timor-Leste, Myanmar, and the Philippines showed stagnation or decline in renewables with variations in environmental burdens. The provisional classification is more apt to be read as a trajectory map than a normative assessment of a "fair" or "unjust" state, because justice cannot be reduced to air quality or energy capacity alone. The perspective of legal sociology demands a follow-up question of whether the social structures that determine the ability of groups of people to benefit, face risks, and participate in development have changed with the transformation of technology.

It is the last question that brings the analysis from environmental issues to social justice issues. PM2.5 can show whether one ecological burden is improving or worsening, but it has not yet shown how capacity to deal with those risks is unevenly structured within society. Gender inequality becomes important in the next stage because reproductive health, empowerment, and economic position determine access to resources as well as the ability of women's groups to respond to socio-ecological change. The next subchapter therefore includes the Gender Inequality Index not as an additional variable, but as a test of whether the progress of the energy transition also moves along with changes in the structure of inequality which is one of the foundations of social justice.

The main discussion contains results and discussion, written in Times New Roman 12 font. Results are not raw data, but data that has been processed/analyzed by a predetermined method. The discussion is a comparison of the results obtained with the existing

[28] X. Chen J. Aleluia, P. Tharakan, A.P. Chikkatur, G. Shrimali, "Accelerating a Clean Energy Transition in Southeast Asia: Role of Governments and Public Policy," *Renewable and Sustainable Energy Reviews* 159, no. 112226 (2022), https://doi.org/https://doi.org/10.1016/j.rser.2022.112226. (https://www.sciencedirect.com/science/article/pii/S1364032122001496).
[29] Roman Vakulchuk, Indra Overland, and Beni Suryadi, "ASEAN's Energy Transition: How to Attract More Investment in Renewable Energy," *Energy, Ecology and Environment* 8, no. 1 (2023): 1–16, https://doi.org/10.1007/s40974-022-00261-6.
[30] Karg, Gupta, and Chen, "Energy Research & Social Science Just Energy Transition Partnerships : An Inclusive Climate Finance Approach ?"

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concepts/theories in the literature review. The contents of the results and discussion include statements, tables, drawings, diagrams, graphs, sketches, and so on.

Gender Inequality and the Emerging Green Transition–Justice Gap

The misalignment between energy transformation and environmental improvement in the previous section does not explain whether the green transition also moves along with changes in the structure of social inequality. The perspective of legal sociology views this issue as important because environmental policy does not work in a neutral social space; Development benefits and risk management are influenced by access to resources, employment, representation, and decision-making. Gender is therefore not positioned as a direct result of the increase in renewable energy, but rather as a structure of inequality that can change at different rhythms of technological and ecological transformation. This approach is in line with the just transition literature which shows that changes in energy systems do not necessarily result in an equitable distribution of benefits, opportunities, and power without the accompanying institutional changes [31][32][33].

The results of the 2016–2023 estimates show a consistent and paradoxical trend: The Gender Inequality Index (GII) improved across the countries analyzed, but the pace differed substantially. Thailand showed the fastest improvement with a Cent slope of around −0.0156 points per year, followed by Malaysia −0.0076, the Philippines −0.0071, Indonesia −0.0067, and Timor-Leste around −0.0060. A slower improvement was seen in Myanmar −0.0055, Brunei −0.0054, Singapore −0.0032, Cambodia −0.0029, and Laos only around −0.0016 points per year. The negative direction in the GII shows a reduction in inequality, so the main problem is not the absence of gender progress, but the inequality of speed between this progress and changes in the energy system and the environment.

The difference in rhythm is most evident when the three trajectories are placed in one comparative framework. Figure 2 presents the standardization of the direction of renewable energy change, environmental improvement, and gender inequality improvement so that the relative position of each country can be compared without equalizing the original units of the three indicators. Positive values indicate a relatively stronger change in the expected direction than the overall sample, while negative values indicate a relatively weaker change or move in the opposite direction. This heatmap is therefore not intended as a ranking of countries, but as a tool for identifying interdimensional asynchronizations in the transition process.

[31] (Tribe)ńska et al., 2021)
[32] Sumarno et al., "Challenges in Increasing Women ' s Participation in the Energy Transition in ASEAN and G7 Countries : A Qualitative Approach Based on the Three Tenets of Justice."
[33] Cellini et al., "Energy Research & Social Science Exploring the Nexus of Gender and Energy Transitions : A Systematic Literature Review."

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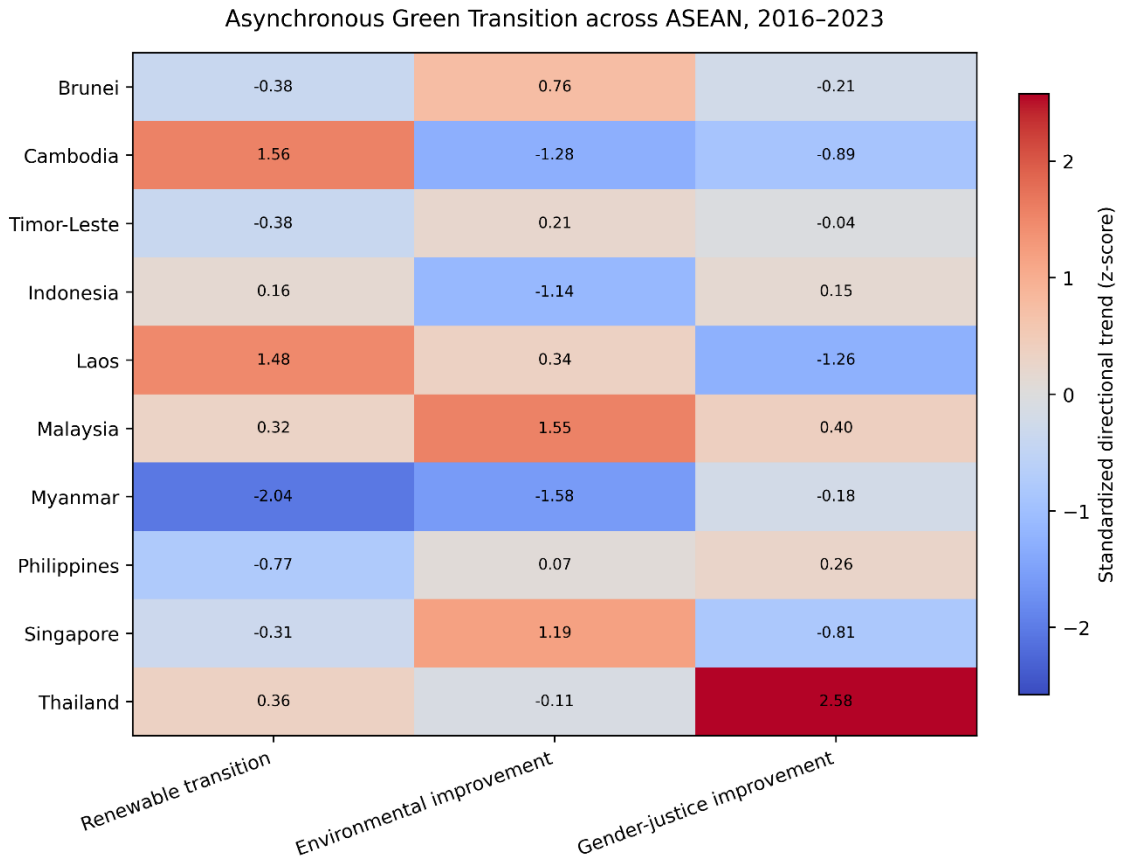

Figure 2. Asynchronous Green Transition across ASEAN, 2016–2023
Source: Author's processing results using Python

The configuration in Figure 2 shows that progress in one dimension cannot be used to predict the position of the country in the other. Thailand has the most prominent gender-justice improvement score of 2.58, but its environmental improvement score is at −0,11; Laos shows an almost opposite configuration with a high renewable transition score of 1.48, but relatively low gender-justice improvement of −1.26. Indonesia is relatively close to the regional average in terms of renewables (0.16) and gender (0.15), but lags behind in environmental improvement (−1.14). Malaysia showed a more balanced configuration with positive scores on renewable (0.32), environment (1.55), and gender (0.40). These differences corroborate the findings [34] that the relationship between energy, development, and gender inequality in Asia is contextual so that progress in the energy sector does not automatically eliminate the inequality structures that are formed through social and economic institutions.

Cambodia provides a more critical case because of relatively strong renewable growth (1.56) in the face of environmental improvement scores −1,28 dan gender-justice improvement −0.89. This position does not mean that Cambodia's gender conditions have absolutely deteriorated as GII continued to decline during the observation period. A negative

[34] Kuşkaya et al., "Spatial Spillover Effects of Gender Inequality on the Path to Energy Transition and Environmental Sustainability in Asia."

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score shows that the pace of improvement is relatively lagging behind other ASEAN countries, while renewable expansion is taking place much faster. This distinction is important to avoid excessive causal conclusions while reinforcing criticism of the use of energy indicators as a single representation of transition success. The literature on just transition also shows that the growth of green investment and technology can be faster than institutional reforms that govern the distribution of benefits, participation, and protection of social groups [35][36]; [37].

The patterns between countries are further summarized in Table 2 to distinguish the trajectory configuration without making it a normative ranking of justice. Malaysia and Singapore are the closest to an aligned green transition because the increase in renewables takes place alongside environmental and gender improvements. Cambodia, Indonesia, Laos, and Thailand are making an environmentally decoupled transition: renewables and GIIs are moving in a better direction, but PM2.5 exposure has not followed that trajectory. Brunei, Timor-Leste, Myanmar, and the Philippines showed stalled/regressive transitions in the energy dimension although GII continued to improve. This classification confirms that regional transitions are more appropriately understood as a layered configuration of change rather than a simple dichotomy between successful and failed states.

Table 2. Country Trajectories of Green Transition, Environmental Burden, and Gender Inequality in ASEAN, 2016–2023

Country	Renewable Sen slope	PM2.5 Sen slope	GII Sen slope	Transition profile
Brunei	0.000	0.041	-0.005	Stalled/Regressive Transition (stable renewables)
Cambodia	2.052	0.438	-0.003	Environmentally Decoupled Transition
Timor-Leste	0.000	0.148	-0.006	Stalled/Regressive Transition (stable renewables)
Indonesia	0.572	0.410	-0.007	Environmentally Decoupled Transition
Laos	1.963	0.121	-0.002	Environmentally Decoupled Transition
Malaysia	0.738	-0.114	-0.008	Aligned Green Transition
Myanmar	-1.745	0.496	-0.005	Stalled/Regressive Transition (declining renewables)
Philippines	-0.405	0.175	-0.007	Stalled/Regressive Transition (declining renewables)
Singapore	0.077	-0.043	-0.003	Aligned Green Transition
Thailand	0.785	0.209	-0.016	Environmentally Decoupled Transition

Note: Negative PM2.5 and GII slopes indicate improvement. Transition profiles summarize the joint direction of the three trajectories.

Source: The author's processing results are based on owid.

The findings produce one more specific empirical proposition: gender inequality is not a dimension that has always been left behind in ASEAN's green transition. Thailand shows that gender improvements can move faster than environmental outcomes, while Laos and Cambodia show that renewable expansion can go beyond changes in the structure of gender inequality. These findings also refine the literature that tends to place women primarily as a vulnerable group in the energy transition; The problem found in ASEAN is not just who is left behind, but institutional inequality in translating technological change into ecological

[35] (Heffron et al., 2024
[36] ; Tunn et al., 2024
[37] Karg et al., 2025)

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and social progress [38][39][40]. This pattern in this study is called asynchronous green transition, which is a state when energy transformation, ecological burden reduction, and changes in social inequality do not move in a comparable direction or speed.

This concept also sets the limit of Results and opens up problems for Discussion. The data shows where the misalignment occurs, but it has not explained why Malaysia is relatively able to align the three trajectories while Cambodia, Indonesia, Laos, and Thailand produce different configurations. This question is no longer sufficiently answered through energy statistics because it touches on regulatory capacity, risk distribution, representation of social groups, and the way in which the law translates the green agenda into substantive protection. The next part of the discussion therefore examines whether ASEAN's green transition–justice gap is an immature technological issue or rather reflects a more fundamental gap between the speed of economic transformation and the capacity of law-social institutions to distribute the results of the transition fairly.

From Green Progress to Justice Gap in ASEAN

The findings of this study show that the fundamental problem of ASEAN's green transition does not lie in the absence of change, but in the inconsistency of change. Renewable electricity production, reduced PM2.5 exposure, and gender inequality amelioration are moving at different speeds even when they take place within the same country and period. Malaysia is relatively close to a harmonic pattern, while Cambodia and Laos show strong renewable growth without comparable environmental and gender improvements; Thailand actually recorded the strongest gender progress when its environmental improvements were relatively lagging behind. This result supports the [41] and [42] that the energy transition cannot be judged solely by technological success because fairness is also determined by how the benefits and burdens of the change are distributed. ASEAN's findings also expand on the argument by showing that the problem is not just the inequality of distribution at one time, but the difference in the speed of transformation between dimensions over time.

An explanation that solely connects renewables with environmental quality is therefore inadequate. A number of studies have found that increasing renewable energy contributes to decarbonization and can reduce emissions in the long term. The study's findings do not disprove the link, but do show its limitations: Cambodia, Indonesia, Laos, and Thailand experienced increases in renewables when PM2.5 exposure had not moved in the same direction. This difference is understandable because electrical decarbonization and air pollution work through non-identical sources and mechanisms; Transportation, industry, biomass burning, and land use can still generate ecological burdens even if the electricity mix becomes greener. These findings support the energy justice criticism that progress on

[38] (Wang & Lo, 2021 ;
[39] Wood et al., 2024 ;
[40] Cellini et al., 2025)
[41] Wang and Lo, “Just Transition: A Conceptual Review.”
[42] Heffron et al., “Defining a ‘Just Energy Investment’ for the ASEAN Just Transition.”

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the energy production side is not synonymous with reduced risks experienced by communities[43][44].

The gender dimension makes the relationship even more complex. The gender and energy transition literature emphasizes that a green economy can open up new jobs, energy access, and participation opportunities for women, but these benefits do not automatically change the division of labor, access to assets, representation, and entrenched power relations [45][46]. Findings in the Spanish job market even suggest that the energy transition can still take place alongside job segregation and structural barriers for women to enter the technical jobs that are thriving in the green economy [47]. ASEAN data supports and corrects this view. Gender is not always the slowest moving dimension: Thailand shows much stronger GII improvements than its environmental improvements, while Laos shows the opposite configuration when renewable progress far outstrips gender change. Gender inequality is thus inappropriately placed simply as an "impact" of the energy transition; Both are institutional processes that can move through different paths and temporalities.

These differences direct the analysis from technology to institutions. The perspective of legal sociology sees law not only as a tool that sets renewable targets, but as a mechanism that links economic transformation with the distribution of rights, risks, opportunities, and protections. Just transition studies show that weak regulation, limited participation, and inequality of access to resources can make green projects perpetuate existing injustices [48][49]. Conversely, an overly deterministic approach to institutions also needs to be avoided because the configurations of Malaysia, Singapore, and Thailand show that socio-ecological progress does not follow a single development model. Institutions are more precisely understood as mediators who determine how far technological changes can be translated into social and ecological changes.

The synthesis of these relationships is formulated in Figure 3. This framework is not intended as a tested causal model, but rather as a theoretical proposition built from empirical patterns of research and dialogue with the literature.

[43] (Tribe)ńska et al., 2021 ;
[44] Wood et al., 2024)
[45] (Sumarno et al., 2024
[46] ; Cellini et al., 2025)
[47] Rosa Santero-Sánchez et al., "Gender Challenges in Just Energy Transition: The Labour Market Perspective," *Energy Research & Social Science* 127 (2025): 104303, https://doi.org/10.1016/j.erss.2025.104303.
[48] (Tunn et al., 2024
[49] ; Karg et al., 2025)

DOI: https://doi.org/10.47353/sibatik.v5i7.5214

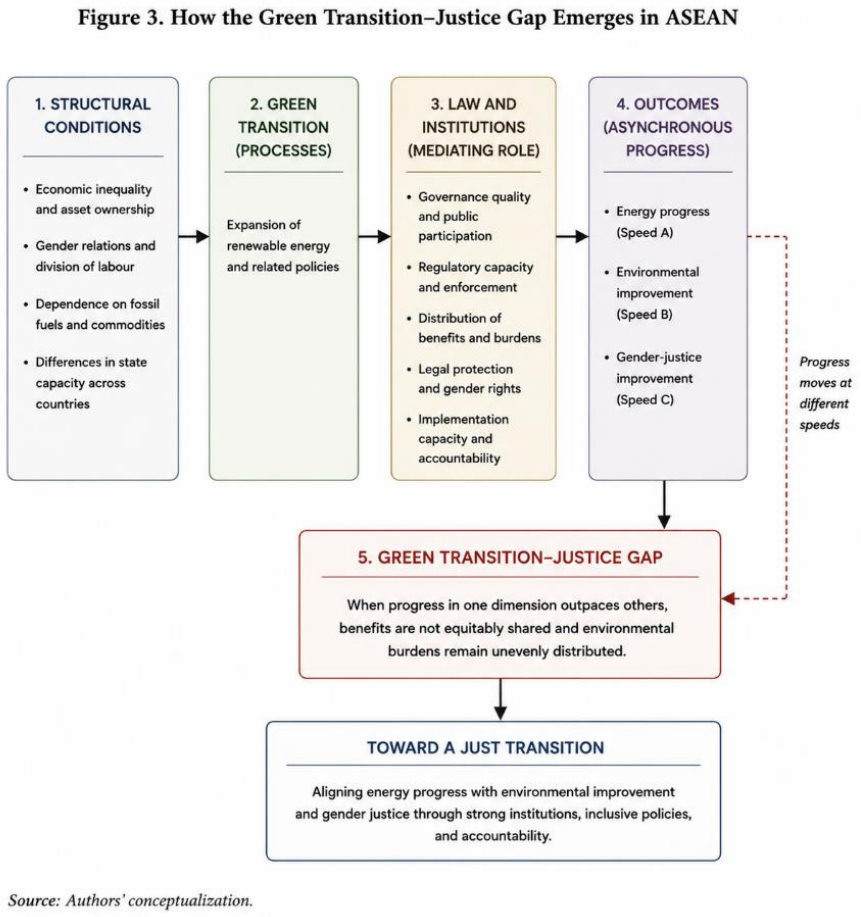

Figure 3. Analytical Framework: Why the Green Transition–Justice Gap Emerges in ASEAN

Figure 3 shows that the green transition–justice gap is formed through three interconnected layers. The initial structure in the form of socio-economic inequality, gender relations, and resource dependence formed the terrain in which the transition took place. Institutional-legal mechanisms—governance quality, regulatory capacity, distributive institutions, rights protection, and integrity of implementation—then mediate how energy change translates into ecological and social outcomes. The difference in mediation capacity produces asynchronous outcomes, namely renewable progress, environmental improvement, and gender-justice improvement that move at different speeds. The equity gap thus arises not because green technology has failed, but because the ability of institutions to translate technological advances into socio-ecological benefits has not developed at the same pace.

This synthesis offers a conceptual shift from just transition as outcome to just transition as synchronization. A just transition is not a state when all indicators have reached the ideal value simultaneously, but rather a process in which technological progress is continuously translated into a reduction in ecological burden and the expansion of social justice without systematically leaving one dimension behind. The implications for ASEAN are quite basic: success is not enough to be measured through renewable capacity or decarbonization targets,

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but needs to be monitored through the distance between the pace of energy change, the environment, and social inequality. Within this framework, the law acquires a more substantive function—not just to legitimize the green transition, but to keep its speed from exceeding the capacity of the community to experience the transition as justice.

CONCLUSION

This research shows that the green transition in ASEAN does not take place as a uniform process between changes in energy, environment, and gender inequality. The longitudinal analysis of 2016–2023 shows that the increase in renewable energy is not always followed by a decrease in PM2.5 exposure or an improvement in gender inequality at a comparable rate. The pattern is formulated as asynchronous green transition, which is a condition when progress in one dimension of the transition moves faster than the other dimension, thus forming a green transition–justice gap. These findings confirm that being greener does not necessarily mean being fairer.

The implication is that the success of the ASEAN transition needs to be assessed beyond the renewable energy capacity indicator by considering changes in environmental burden and social inequality at the same time. Law and institutions have an important position in linking technological transformation to benefit distribution, environmental protection, participation, and gender justice. Further research can test the asynchronous green transition framework using institutional indicators and more detailed distributional data to explain the mechanisms that produce the differences in trajectories between countries.

The contents of the conclusion are written in Times New Roman 12. The conclusion is an overview based on the research that has been done. The conclusion is not a summary of the results of the discussion that refers to a particular theory, but the results of the analysis/correlation test of the data discussed.

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