Institutional and Political Economy Constraints in Advancing Inclusive Low-Carbon Renewable Energy Transitions in Indonesia: A Systematic Literature Review

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Abstract

Indonesia's commitment to achieving a 23% renewable energy share by 2025 reflects an ambitious pathway toward low-carbon development; however, progress remains slow and uneven. This study systematically reviews the literature to examine how institutional arrangements, political economy dynamics, financing mechanisms, and energy justice considerations shape renewable energy deployment in Indonesia. Using a systematic literature review (SLR) approach guided by PRISMA, the study synthesizes peer-reviewed research addressing regulatory frameworks, the role of the state-owned utility PLN, investment and financing structures, and community inclusion. The findings reveal that entrenched institutional interests, centralized governance, and fossil fuel–oriented incentives constrain renewable energy scalability, while fragmented regulations undermine investor confidence and local participation. At the same time, evidence highlights that decentralized and community-based renewable energy models, when supported by credible regulations and tailored financing instruments, can enhance both bankability and social equity. The review also identifies persistent justice gaps, particularly distributive and procedural injustices affecting rural and marginalized communities. By integrating insights across policy, finance, and justice dimensions, this study contributes a holistic understanding of Indonesia's energy transition challenges and underscores the need for coordinated reforms that align regulatory credibility, inclusive financing, and participatory governance to achieve an equitable low-carbon transition.

Keywords: renewable energy transition; institutional governance; political economy; energy justice; Indonesia

1. Introduction

Over the past decade, renewable energy development has increasingly shaped Indonesia's low-carbon development pathway by expanding energy capacity and diversifying supply away from

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conventional fossil sources. This strategic direction is reflected in national policy targets that aim to raise renewable energy's share to 23% by 2025, yet recent evidence indicates that actual deployment is falling short, with one assessment reporting an annual increase of only 0.55% [1]. The resulting ambition–implementation gap is particularly salient because Indonesia's transition agenda depends not only on scaling installed capacity, but also on improving system resilience and reducing exposure to climate risks. In this regard, investment in key technologies, especially solar and geothermal, has been positioned as essential to delivering a reliable low-carbon system, with decentralized energy architectures frequently highlighted as pathways to improve efficiency and resilience [2,3]. As renewable penetration increases, enabling technologies such as energy storage become increasingly material to balancing variable supply and supporting renewable energy communities, reinforcing the systemic nature of the transition challenge [4].

However, Indonesia's ability to meet its renewable targets is constrained by structural and institutional factors that extend beyond technology availability. Despite initiatives associated with national-level coordination bodies, the persistent gap between formal goals and realized deployment is widely attributed to inadequate regulatory frameworks and limited local implementation capacity [3]. These deficits are compounded by fragmented governance and coordination problems across levels of government, as well as limited stakeholder engagement in planning and implementation processes [2]. At the regional level, investment attraction and project delivery remain uneven across ASEAN contexts, and Indonesia's transition is further complicated by economic dependencies and political–economic incentives that continue to privilege fossil-fuel pathways, thereby slowing renewable investment and scaling [5]. Together, this literature suggests that improving policy design and institutional effectiveness is not ancillary but foundational for accelerating renewable deployment.

Against this backdrop, inclusive low-carbon development has become a central lens for assessing the quality of Indonesia's energy transition. In the Indonesian context, inclusive low-carbon development is commonly conceptualized as integrating environmental sustainability with social equity so that marginalized communities can access and benefit from renewable energy deployment, through improved energy access, livelihood opportunities, and reduced exposure to environmental harms [6]. These framing positions renewable adoption not as a purely technological substitution, but as a socio-institutional transformation that must also address economic disparity, enable community participation, and align transition outcomes with national climate and development goals [6]. Empirical and policy-oriented work underscores that participatory governance and equitable access to resources are preconditions for operationalizing this approach, particularly where multiple actor interests and sectoral priorities shape transition trajectories [7,8].

Nevertheless, evidence also indicates that renewable energy deployment often reproduces, rather than resolves, existing inequalities across social, economic, and regional dimensions. Despite substantial renewable potential, implementation can overlook rural and impoverished areas, intensify distributional disparities and raise ethical concerns about who bears transition burdens and who receives benefits [8,9]. Low-income communities may face compounded barriers, limited access to capital, education, and technology, reducing their ability to participate in and benefit from renewable programs and associated mobility or sectoral transition policies [10,11]. Moreover, broader governance and institutional inefficiencies can obstruct equitable outcomes, especially in less developed regions where administrative capacity, service provision, and infrastructure connectivity are weaker [12, 13]. These challenges imply that "scaling" renewables without deliberate equity mechanisms risks undermining the legitimacy of the transition and limiting its developmental co-benefits.

Community acceptance, participation, and trust therefore emerge as decisive conditions for

successful renewable deployment in Indonesia. Reviews of renewable integration for climate resilience emphasize the role of social acceptance and coordinated engagement in reducing resistance and increasing implementation effectiveness [14]. Complementing this, scholarship on renewable energy access and equity highlights how participatory decision-making and inclusion-oriented program design can strengthen trust and improve outcomes for marginalized groups [15]. Capacity building and community-focused transition approaches are similarly argued to be important for ensuring that renewable projects deliver tangible social benefits rather than merely redistributing infrastructure [15]. In combination, these perspectives suggest that community adoption is not merely a contextual variable but a central driver of deployment continuity, project performance, and fairness.

At the same time, Indonesia's electricity transition is shaped by the dominance of the state-owned utility Perusahaan Listrik Negara (PLN), whose centralized control affects the pace and inclusiveness of renewable integration. Policy analyses indicate that PLN-centered governance structures can create regulatory and operational bottlenecks that slow the expansion of decentralized renewable solutions, particularly where grid access, procurement arrangements, and institutional incentives remain aligned with conventional generation priorities [16]. More broadly, governance research emphasizes that energy transitions are complex and multi-layered, and that interactions between policy instruments, institutional arrangements, and socio-technical dynamics frequently determine whether reforms translate into real deployment outcomes [17]. In Indonesia, concerns have also been raised that pricing strategies and investment priorities may insufficiently address rural and outer regions, potentially reinforcing inequalities in energy access and undermining inclusivity objectives [18].

Although Indonesia provides the primary empirical context of this review, its experience should not be interpreted as an isolated national case. Indonesia represents an analytically important setting for examining low-carbon transitions in emerging economies because it combines a large and geographically dispersed electricity system, a dominant state-owned utility, persistent fossil-fuel dependence, uneven institutional capacity, and substantial regional disparities in energy access and investment. These characteristics distinguish Indonesia from countries where electricity markets are more decentralized, utility structures are more competitive, or renewable-energy deployment is supported by more mature financing and regulatory institutions. At the same time, several challenges observed in Indonesia, including incumbent resistance, regulatory uncertainty, investment risk, subsidy dependence, and tensions between renewable deployment and distributive justice, are also reported across other developing and emerging economies [3, 5]. Indonesia therefore provides a useful case through which broader questions concerning how governance structures, political-economic interests, and justice considerations shape low-carbon transitions can be examined. Accordingly, this review treats Indonesia not only as the geographical scope of the evidence synthesis but also as a case for identifying mechanisms that may be context-specific and mechanisms that may be transferable across emerging-economy energy transitions.

Motivated by these interconnected challenges, this Systematic Literature Review (SLR) synthesizes evidence on inclusive low-carbon development in Indonesia by focusing on the interaction between community adoption, financing dynamics, and regulatory design as determinants of renewable energy scale-up. The review addresses four interrelated research questions:

(1) How community adoption conditions influence renewable energy deployment outcomes.

(2) Which financing structures and de-risking mechanisms most strongly shape bankability and scale-up.

(3) How regulatory design choices, particularly tariffs, power purchase agreements, incentives, and grid rules, interact with PLN's institutional role to enable or constrain inclusive scale-up.

(4) What integrated policy and research agenda can best align inclusion, bankability, and regulatory credibility.

The remainder of this article is organized as follows: Section 2 details the review methodology; Section 3 develops the theoretical background; Section 4 synthesizes findings across four themes; Section 5 discusses implications for policy, practice, and research; and Section 6 concludes by identifying gaps and priorities for future work.

2. Methods

This study employed a systematic literature review (SLR) design to synthesize evidence on inclusive low-carbon development in Indonesia, focusing on the interaction between community adoption, financing dynamics, and regulatory design for renewable energy scale-up. The review protocol is developed to maximize transparency, replicability, and methodological rigor, drawing on widely used structured SLR guidance in energy-transition research and related policy-facing reviews [19–21]. We adopted the PRISMA logic for systematically identifying, screening, and selecting studies, while allowing targeted adaptations aligned with the interdisciplinary character of energy-transition scholarship and its socio-economic dimensions [17,22].

2.1. Search Strategy

The primary database is Scopus, complemented by targeted cross-checking in Google Scholar and reference chaining from included studies to improve recall and reduce database bias, consistent with established practice in policy- and systems-oriented energy reviews [19,20]. Search strings are constructed using Boolean operators and keyword clusters covering: (1) renewable energy and Indonesia; (2) community adoption, participation, acceptance, justice, and equity; (3) financing and bankability (e.g., incentives, tariffs, de-risking, investment); and (4) regulation, governance, licensing, grid rules, and PLN. Terms are iteratively refined by examining keywords and index terms from relevant transition and policy studies and by testing for sensitivity across multiple runs.

The search is delimited to peer-reviewed journal articles and high-quality conference outputs in English to enhance quality control and comparability. The temporal window is aligned with the recent surge in Indonesian energy-transition policy debates and evidence generation, while allowing inclusion of earlier works when repeatedly referenced as foundational in the retrieved corpus. The search approach is informed by evidence that renewable energy transitions in developing contexts depend on institutional design, policy implementation capacity, and investment conditions, making broad coverage across technical, legal, and socio-political domains essential [5,16]. In addition, as this SLR centers on inclusive low-carbon development, search terms are intentionally expanded to capture scholarship on social equity and access in energy transitions and governance systems [13,15].

2.2. Eligibility Criteria

Inclusion criteria are designed to ensure direct relevance to the review's core argument while retaining interdisciplinary breadth. Studies are included if they: (a) focused on Indonesia's renewable energy transition (national or subnational) or presented Indonesia-specific results in comparative work; (b) addressed at least one of the focal dimensions, community adoption and participation, financing/bankability, or regulatory/institutional design; and (c) provided

sufficient methodological transparency (e.g., data sources, analytical steps, or model assumptions). Studies engaging explicitly with justice, equity, and distributional concerns are retained even when renewable deployment outcomes are discussed indirectly, given the conceptual centrality of inclusive low-carbon development [8,9,11].

The exclusion criteria comprised: (a) studies not specific to Indonesia (unless Indonesia evidence is separable); (b) narrowly technical engineering studies with no implications for deployment, policy, finance, or social inclusion; and (c) commentary pieces lacking analytical grounding. Because the review integrates socio-economic, legal, and governance evidence, we treated "policy relevance" broadly, encompassing work on climate risk and system resilience [2], affordability and accessibility concerns [12], and legal-institutional perspectives on solar investment policy [3]. Studies addressing macro political economy and investment conditions are considered eligible when they provide implications for renewable scaling trajectories [1,6,23].

2.3. Screening and Selection Process

Screening followed PRISMA stages: identification, title/abstract screening, full-text eligibility assessment, and final inclusion. Records are duplicated prior to screening. Title/abstract screening applied the eligibility criteria to remove out-of-scope studies efficiently, followed by full-text review to confirm thematic relevance and methodological adequacy. The process is documented in a PRISMA flow diagram as shown in Figure 1, which reports the number of records identified, screened, excluded (with reasons), and included.

PRISMA method is applied as the primary reporting backbone, consistent with energy-transition SLR practice [19,20]. To accommodate heterogeneous evidence (qualitative case studies, legal analysis, econometrics, and systems modeling), we used a structured "search–appraisal–synthesis" logic consistent with SALSA-type reasoning that is frequently paired with PRISMA in applied sustainability reviews [22]. This combination supports transparency in how diverse evidence types are integrated into a coherent synthesis.

2.4. Quality Appraisal, Data Extraction, and Synthesis

Given the mixed-method nature of the evidence base, quality appraisal used a hybrid approach informed by established tools for multi-design evidence. For studies combining qualitative and quantitative components, appraisal followed principles consistent with the Mixed Methods Appraisal Tool (MMAT), which is commonly recommended for reviews spanning varied methodologies [24]. Qualitative-dominant studies are additionally assessed using criteria aligned with the Critical Appraisal Skills Programme (CASP), reflecting the need for robust evaluation of interpretive evidence in complex transition contexts [25]. Appraisal focused on clarity of research questions, appropriateness of study design, transparency of data and analysis, credibility of inferences, and limitations.

A standardized extraction form is applied to all included studies. Extracted fields included bibliographic metadata, geographic locus, technology/sector focus, study design and data sources, regulatory instruments (e.g., tariffs, incentives, licensing, grid rules), financing constructs (e.g., cost of capital proxies, de-risking mechanisms), community adoption mechanisms (e.g., participation, trust, capacity building), and reported outcomes (deployment, equity/justice implications, implementation barriers). Data extraction practices are aligned with guidance emphasizing structured capture of comparable parameters and subsequent thematic synthesis to identify recurring patterns and mechanisms [21,26].

Synthesis used a thematic approach to integrate heterogeneous findings into four themes (community adoption; financing/bankability; regulatory design; institutional–political economy and justice outcomes). Thematic synthesis is selected because it supports interpretive integration across methods and enables linking micro-level adoption evidence with meso-level regulatory design and macro-level investment dynamics. This approach is widely used to translate diverse evidence into actionable insights, including in policy-facing systematic reviews beyond the energy domain. For interpretive consistency, we maintained an explicit chain-of-logic from adoption conditions to finance ability and regulatory credibility, reflecting the multi-level governance complexity emphasized in energy-transition scholarship [16, 17].

Finally, to preserve alignment with the "inclusive low-carbon development" objective, the synthesis coded justice and equity considerations where reported (e.g., distributive and procedural dimensions), including in studies addressing subsidy reform and transition fairness [11], access and inclusion in developing contexts [15], and sectoral transition narratives in Indonesia [18].

3. Theoretical Background

3.1. Relevant Theories and Models

This review integrates complementary theoretical lenses to explain why Indonesia's renewable energy scale-up is simultaneously a technological, institutional, and distributive challenge. First, socio-technical transition theory, particularly the multi-level perspective (MLP), conceptualizes transitions as interactions across niches (innovation spaces), the regime (dominant rules, infrastructures, incumbent actors), and the landscape (macro pressures such as climate risk, global finance, and social expectations). The MLP is especially useful for electricity systems dominated by incumbents because it foregrounds the tension between niche-level experimentation and a regime that tends to prioritize stability, sunk-cost recovery, and operational predictability over disruptive change. In such systems, breakthroughs are unlikely to be explained by technology alone; rather, niche innovations (e.g., decentralized renewables, storage-enabled communities, smart grid applications) must be supported by shifts in procurement and finance arrangements and by institutional reconfiguration that can destabilize incumbent lock-in under landscape pressures [4, 27].

Second, energy justice frameworks are used to evaluate whether transitions are not only fast, but also fair. In developing contexts, distributive, procedural, and recognition justice are increasingly mobilized to assess who receives transition benefits, who bears burdens, whose voices shape decisions, and which groups are acknowledged as legitimate claimants in energy governance [28–30]. Distributive justice is particularly relevant where uneven infrastructure development and affordability constraints risk excluding poorer households or peripheral regions; procedural justice emphasizes meaningful participation and consent; and recognition justice highlights historical and identity-based marginalization that may be reproduced when projects are planned without local legitimacy or culturally appropriate engagement [9, 13, 15]. These justice lenses align with Indonesia-focused scholarship that frames the energy transition as a development strategy that must reconcile decarbonization with equity, community participation, and climate-risk resilience [2, 6].

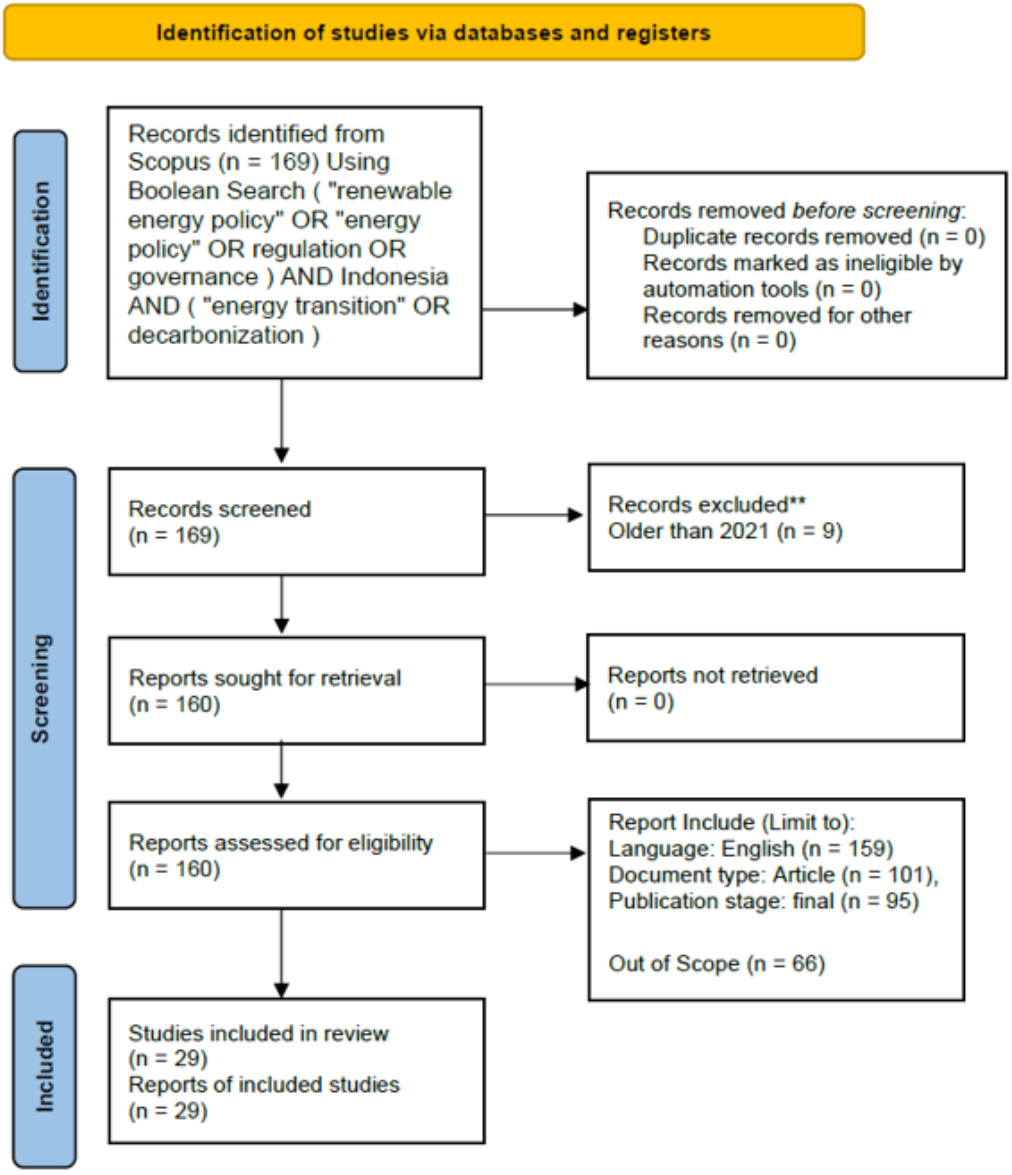

Figure 1: *The PRISMA flow diagram detailing the screening and selection process of literature*

Third, the review draws on regulatory and political economy perspectives that link investment incentives, procurement design, and policy credibility to observable deployment outcomes. This literature emphasizes that renewable diffusion depends on investor expectations of stable rules (e.g., tariffs, PPAs, grid access), while also accounting for affordability, fiscal constraints, and distributional impacts. Comparative and integrative reviews show that fossil-fuel subsidies can distort relative prices and reduce renewable competitiveness, while reform pathways must consider equity and political feasibility [11]. Similarly, work on investment policy and legal frameworks highlights that the credibility of solar and other renewable investment regimes depends on enforceable rules, streamlined processes, and coherent incentive structures [3, 19]. These models are complemented by sectoral assessments that situate Indonesia's transition within broader

ASEAN investment dynamics and market integration pressures [6,23].

Finally, because transition analysis increasingly relies on cross-sector indicators and applied sustainability metrics, this review also acknowledges indicator-driven approaches that track renewable transition performance and co-benefits. Indicator reviews can clarify measurement choices and trade-offs when assessing sustainability outcomes and policy effectiveness, even across adjacent domains such as agriculture and the built environment [21,22]. While not specific to Indonesia's electricity sector, these approaches help structure how evidence is compared across heterogeneous study designs, an important consideration for synthesizing mixed evidence bases, as highlighted by protocol-oriented scholarship on multi-method reviews [24,25].

3.2. Historical Development of the Topic

Indonesia's renewable energy policy and regulatory architecture have evolved through repeated attempts to create investable incentives and to manage the institutional realities of a utility-dominated electricity sector. A key early policy move is the introduction of feed-in tariffs (FiTs) beginning in 2011, initially oriented to geothermal and later expanding coverage to other renewable technologies, reflecting a shift toward fixed-price mechanisms intended to stimulate private investment and accelerate diffusion [16,31,32]. Over time, Indonesia's incentive toolkit and tariff approaches have continued to change, informed by comparisons with other developing and developed contexts and by debates over how to calibrate tariff incentives to technology costs and deployment risks [33]. Empirical policy evaluations further suggest that "green energy" policies and infrastructure expansion can affect renewable investment and regional economic outcomes, albeit unevenly across locations and governance capacities [34].

Alongside pricing reforms, regulatory evolution has been shaped by persistent administrative and institutional bottlenecks. Policy commentary and national assessments repeatedly note that bureaucratic complexity and licensing uncertainty can reduce project bankability and slow deployment, motivating calls for further streamlining and clearer regulatory pathways [1,18,36]. In parallel, system modernization agendas, such as smart grid development, have gained prominence as a means of integrating variable renewables, improving reliability, and enabling decentralized solutions, though implementation faces technical and governance constraints [27]. Indonesia's longer-term transition trajectory is also increasingly conditioned by regional pressures and opportunities, including ASEAN-level market integration initiatives that require harmonization and infrastructure readiness [23] and regional investment conditions that influence how quickly capital can be mobilized for renewables [5].

A defining historical feature of Indonesia's electricity transition is the dominant role of PLN and the persistence of fossil-fuel-centric procurement patterns. Policy reviews argue that utility-centered governance structures can reinforce path dependency and slow renewable uptake when institutional incentives and operational priorities remain aligned with incumbent technologies [16]. These dynamics are not unique to Indonesia: island-system reviews and resilience-focused syntheses highlight that governance and institutional design often determine whether technical solutions translate into sustainable deployment [14,20]. Consequently, Indonesia's policy history can be read as iterative experimentation with pricing and institutional reforms, in which progress depends on whether new incentives successfully realign regime-level procurement, investment, and implementation capacity.

3.3. Ongoing Debates and Controversies

A central debate in Indonesia's renewable policy design concerns tariff adequacy versus affordability. FiTs and tariff incentives are intended to improve project economics and reduce investor uncertainty, yet they raise concerns about consumer price impacts and fiscal sustainability, particularly for low-income households. Comparative analyses stress that balancing these objectives requires nuanced tariff structures and complementary support mechanisms targeted to vulnerable groups, rather than uniform price increases that could be socially regressive [11,33]. Related work shows that policy signals can influence investment outcomes, but that investor responsiveness is mediated by credibility, implementation capacity, and broader political economy conditions [18,34]. In this debate, fossil-fuel subsidies are frequently identified as a structural distortion: by lowering the effective price of conventional energy, subsidies can blunt renewable competitiveness and prolong lock-in, implying that subsidy reform is intertwined with tariff reform and must be designed with equity safeguards [11].

A second debate concerns the trade-offs between centralized utility-led transitions and decentralized or community-based renewable models. Centralized approaches may achieve economies of scale and simplified coordination but can struggle to address diverse local needs and may under-serve rural or marginalized communities. Decentralized models can enhance access, empowerment, and resilience but often face constraints in finance ability, technical capacity, and governance support [2,35]. Comparative governance research further argues that trust in processes and institutional legitimacy influence whether stakeholders accept transition decisions, suggesting that both centralized and decentralized models require credible, participatory governance to avoid resistance and implementation failures [15]. Technology trajectories, especially the growing importance of energy storage, also shape this debate because storage can expand the feasibility of local renewable communities while raising new questions about standards, ownership, and equitable benefit distribution [4].

A third controversy involves how to evaluate "success" in transitions: whether emphasis should fall primarily on installed capacity and emissions, or also on equity, resilience, and broader development outcomes. Energy justice scholarship cautions that rapid deployment can still be unjust if burdens concentrate on marginalized populations or if decision-making excludes affected groups [28–30]. Indonesian and developing-context studies highlight ethical dilemmas and contested claims about what constitutes responsible transition practice, including the distribution of risks across communities and the governance of natural resources and infrastructure [9,13,37]. In operational terms, this implies that transition evaluation must integrate affordability and access [12], climate resilience [2,14], and sector-specific "just transition" concerns such as biofuel governance and multi-actor dynamics [8]. Even seemingly distant literatures on implementing "inclusive" reforms in other public domains underline a common lesson: inclusion requires deliberate design, capacity building, and monitoring, otherwise reforms may remain nominal rather than effective.

Synthesizing these debates, this review uses the MLP and energy justice frameworks to interpret Indonesia's renewable scale-up as a multi-level governance problem: niche innovations (community renewables, storage, smart grids) must become financeable and institutionally credible within a regime shaped by procurement rules, subsidy structures, and incumbent utility priorities, while landscape pressures (climate risk, regional integration, global investment dynamics) raise the costs of delay and the stakes of inequity [5,17,23,38].

4. Review of Findings

4.1. Community Adoption, Awareness, and Participatory Pathways

This subsection synthesizes empirical and conceptual evidence on how community awareness, participation, institutional conditions, and governance arrangements shape the adoption of renewable and low-carbon energy initiatives in Indonesia. Table 1 summarizes six core studies that collectively illustrate that adoption outcomes are not primarily constrained by technology availability, but by socio-institutional factors such as awareness levels, land tenure security, intermediary support, and participatory governance mechanisms.

Table 1: *Evidence base on community adoption, awareness, and participatory pathways for renewable/low-carbon energy scale-up in Indonesia*

Refs.	Research context	Methodology	Key findings	Strengths / limitations
Ref. [39]	Sulawesi, Indonesia (Jeneponto, Pangkep, Polewali Mandar, Majene); renewable energy projects implementation	Mixed methods: 400 resident surveys + qualitative interviews with government, NGOs, private sector	Public awareness remains low: only 27% of respondents show basic knowledge of renewable energy; rural unfamiliarity exceeds 70%. Education and income significantly correlate with awareness. Adoption can be accelerated through multisector collaboration and culturally adapted engagement strategies under regulatory and financial constraints.	Strength: integrates public perception and stakeholder dynamics with a large sample. Limitation: region-specific; focuses more on awareness than measured adoption outcomes.
Ref. [40]	Five Indonesian cities; household rooftop solar uptake	Survey-based stated-preference quantitative study	Identifies household-level economic and non-economic attributes shaping interest in rooftop solar across urban contexts, supporting targeted adoption programs.	Strength: multi-city household evidence. Limitation: preference-based data may not translate into realized adoption.
Ref. [41]	Indonesia; community-based solar projects; land tenure arrangements	Conceptual and case-based institutional analysis using Ostrom's socioecological systems framework	Adoption depends on land tenure transformation and coproduction of tenure arrangements; tenure insecurity undermines community buy-in and project continuity.	Strength: highlights institutional barriers often absent in techno-economic studies. Limitation: context-dependent generalizability.

Refs.	Research context	Methodology	Key findings	Strengths / limitations
Ref. [42]	Indonesia; community-scale refuse-derived fuel (RDF) systems	Participatory community intervention with environmental education	Community empowerment and participatory education enable acceptance of RDF as a dual energy-waste solution and support energy self-sufficiency cycles.	Strength: centers empowerment as an adoption mechanism. Limitation: lacks long-term adoption and performance metrics.
Ref. [35]	Cross-country cases including Indonesia; community energy models	Institutional analysis using Ostrom's framework	Centralized systems limit participatory energy planning; intermediaries are critical for initiating and sustaining community adoption where regulatory support is weak.	Strength: links adoption to intermediary and policy design. Limitation: limited Indonesia-specific outcome data.
Ref. [43]	ASEAN incl. Indonesia; rural microgrids	Mixed methods: techno-economic analysis, governance and business model review	Microgrids enhance access and community empowerment; adoption shaped by governance models, justice outcomes, and market liberalization prospects.	Strength: integrates justice, governance, and adoption. Limitation: overview-level synthesis with limited local granularity.

Across these studies, quantitative evidence indicates that low awareness remains a fundamental bottleneck. Ref. [39] reports that only 27% of surveyed residents possess basic renewable energy knowledge, with rural unfamiliarity exceeding 70%, underscoring why adoption remains limited despite policy targets. This gap aligns with national-level assessments showing Indonesia's renewable energy share increasing by only 0.55% annually, far below the 23% target for 2025 [1]. Ref. [40] further demonstrates that even in urban contexts, adoption depends on household-specific economic and behavioral attributes, reinforcing that diffusion pathways require differentiated, context-sensitive design rather than uniform incentives.

Institutional and governance dimensions emerge as equally decisive. Ref. [41] shows that insecure or contested land tenure directly erodes community commitment and project continuity, while Ref. [35] identifies intermediaries as necessary adoption enablers in Indonesia's centralized energy regime. These findings are consistent with broader analyses highlighting fragmented governance, limited stakeholder engagement, and regulatory constraints as structural barriers to renewable energy deployment [3,5,36].

Participatory pathways that emphasize empowerment and justice provide partial mitigation. Ref. [42] illustrate how participatory education and co-management enable acceptance of refuse-derived fuel systems, while Ref. [43] demonstrate that microgrid adoption improves when governance arrangements explicitly address access, employment, and distributive outcomes. These insights align with justice-oriented perspectives on inclusive low-carbon development, which emphasize procedural inclusion, equitable access, and community trust as prerequisites for sustained adoption [6,8,9,11,23].

Collectively, the evidence indicates that community adoption in Indonesia is constrained less by technological feasibility than by socio-institutional readiness. Awareness deficits quantified at

over 70% in rural areas, dependence on intermediaries, tenure insecurity, and centralized utility dominance converge to slow uptake. Addressing these barriers requires integrated strategies combining targeted awareness programs, institutional reform, intermediary support, and participatory governance, thereby aligning renewable energy deployment with inclusive low-carbon development objectives.

4.2. Financing Dynamics and Bankability for Renewable Energy Scale-Up

This subsection synthesizes the evidence on how financing structures, tariff design, risk allocation, and broader political–economic conditions shape the bankability of renewable energy projects in Indonesia. Table 2 consolidates eleven key studies demonstrating that while renewable technologies are increasingly cost-competitive, misaligned incentives, regulatory uncertainty, and fossil-fuel–biased finance continue to constrain private and blended investment flows.

Table 2: *Financing Dynamics and Bankability for Renewable Energy Scale-Up in Indonesia*

Refs.	Geographical scope	Analytical framework	Key results (finance/bankability)	Implications for policy & practice
Ref. [44]	Indonesia; Nias Island utility-scale PV (26 MW); PLN vs IPP	Techno-economic feasibility modelling (RETScreen) under new PV tariff	Project not financially feasible for IPPs under current PV tariffs; becomes viable with $\sim$USD 10/tCO_2 incentive; highly profitable for PLN due to de-dieselization savings	Reveals tariff–bankability gap; supports carbon-linked incentives, tariff reform, and risk-sharing to align PLN system benefits with IPP returns
Ref. [45]	Indonesia (34 provinces; household PV)	Agent-based modelling + supply-chain optimization	Policy interventions raise adoption intention, but financial and facility constraints prevent realization; policy mixes outperform single instruments	Financing must address affordability and delivery constraints; bundled incentives are more effective
Ref. [46]	Indonesia; geothermal sector (Dieng 70 MW)	SWOT analysis + project case study	High upfront capital, exploration risk, and tariff/PPA uncertainty raise cost of capital and undermine bankability	Supports public de-risking, drilling insurance, guarantees, and standardized bankable PPAs
Ref. [18]	Indonesia (national)	Integrative policy and strategy analysis	Unreliable government financing mechanisms identified as core barrier to RE scaling	Emphasizes diversified financing channels, PPP readiness, and credible incentives

Refs.	Geographical scope	Analytical framework	Key results (finance/bankability)	Implications for policy & practice
Ref. [47]	Indonesia (political economy)	Subsidy and investment-signalling analysis	Fossil subsidies slow transition; subsidy reform feasible with social protection; rooftop PV ROI constrained by regulation	Highlights subsidy reform as financing lever and need for pro-ROI PV rules
Ref. [48]	D8 countries incl. Indonesia (2000–2023)	Panel econometrics (System-GMM, CCE, DK)	Foreign finance significantly boosts RE supply/demand; globalization amplifies effects	Calls for institutional strengthening and channeling FDI into renewables
Ref. [49]	Top 10 CO_2 emitters incl. Indonesia	Econometric energy-trilemma analysis	Fixed-asset investment supports growth but risks environmental harm	Finance strategies must balance security, equity, and sustainability
Ref. [50]	Indonesia (macro-fiscal)	Stock-flow consistent EIRIN modelling	Transition spillovers raise debt and stranded-asset risk by mid-century	Necessitates fiscal planning and sovereign de-risking for RE finance
Ref. [51]	Indonesia (coal finance)	Political-economy analysis	Cross-border coal finance prolongs fossil dependence	Calls for fossil-finance governance and transition-aligned disclosure

Across the reviewed studies, a recurring quantitative signal is the persistence of a tariff–bankability mismatch. Ref. [44] demonstrates that a 26 MW utility-scale solar PV project on Nias Island is financially unviable for independent power producers under current tariffs yet becomes viable with a relatively modest carbon incentive of approximately USD 10 per ton of CO_2. In contrast, the same project is highly profitable for PLN due to avoided diesel generation costs, illustrating how system-level benefits are not transmitted to private investors. Similar misalignments are evident at the household scale: Ref. [45] shows that across 34 provinces, policy interventions increase willingness to adopt rooftop PV, but financial and facility constraints prevent conversion of intention into actual installation, indicating that affordability remains binding even when technology acceptance is high.

Capital intensity and risk allocation further undermine bankability in strategic sectors. Ref. [46] identifies geothermal exploration risk, high upfront costs, and tariff and PPA uncertainty as dominant drivers of elevated cost of capital, while Ref. [18] highlights unreliable public financing mechanisms as a systemic barrier at the national level. These project-level findings are reinforced by macro-financial evidence. Ref. [48], using panel data from 2000–2023, finds that foreign finance significantly increases renewable energy deployment in developing economies, including Indonesia, especially under higher globalization. However, Ref. [50] cautions that unmanaged transition spillovers can raise sovereign debt and stranded-asset risks by mid-century, underscoring the need for coordinated fiscal and de-risking strategies.

Political–economic conditions shape relative bankability across technologies. Refs. [47] and [51] show that fossil fuel subsidies and continued access to coal finance crowd out renewable investment, even as renewables become more cost competitive. At the same time, targeted

regulatory design can alter investment signals: the biomass co-firing assessment indicates that moderate co-firing ratios of around 5% can lower emissions intensity and levelized costs, whereas poorly calibrated requirements raise costs and deter investment. Taken together, the evidence indicates that Indonesia's renewable energy financing challenge is not a shortage of capital per se, but a misalignment of tariffs, risk-sharing mechanisms, subsidy structures, and fiscal safeguards. Resolving these misalignments is essential for improving bankability and enabling inclusive low-carbon development on a scale.

4.3. Review of Findings: Regulatory Design, Permitting, and Market-Rule Levers Shaping Renewable Energy Scale-Up in Indonesia

The findings in Table 3 show that regulatory design in Indonesia systematically shapes not only the pace of renewable energy deployment but also the distribution of risks, costs, and benefits across actors and regions. At the project and technology level, tariff regulation emerges as a decisive lever. Evidence from utility-scale solar and biomass cases demonstrates a persistent misalignment between system-level economic value and private investor returns. In the 26 MW Nias Island PV case, the new tariff renders projects infeasible for IPPs while remaining profitable for PLN due to de-dieselization savings, a gap that can be closed by introducing a modest carbon-linked incentive of approximately USD 10/tCO_2 [45]. A similar pattern is observed in biomass power development in Kundur Island, where tariff differentiation between initial and expansion phases produces sharply divergent feasibility outcomes for IPPs, even as PLN continues to benefit from avoided diesel costs [53]. These findings indicate that tariff instruments, when designed without explicit mechanisms to share avoided-cost benefits, risk reinforcing incumbent advantages and discouraging private and local participation.

On the household and decentralized scale, regulatory effectiveness depends less on single instruments and more on policy coherence and delivery capacity. Simulation results covering all 34 provinces and grounded in a 413-household empirical survey show that export tariffs, investment incentives, and environmental campaigns can raise adoption intentions, yet intention frequently fails to translate into actual installation because of affordability constraints and supply-side limitations [45]. Quantitatively, combined policy packages consistently outperform single measures in reducing emissions and costs, underscoring that market rules must be complemented by installer availability, grid interconnection readiness, and consumer protection. These results resonate with broader assessments of feed-in tariffs, which identify pricing logic, payment certainty, and grid access as necessary but insufficient conditions for sustained scale-up [53].

Table 3: *Regulatory design, permitting, and market-rule levers shaping renewable energy scale-up in Indonesia*

Refs.	Sample / policy locus	Regulatory instrument(s) assessed	Outcomes for RE scale-up (as reported)	Critical notes for inclusive regulatory design
Ref. [44]	Utility-scale PV; 26 MW Nias Island; compares IPP vs PLN perspective	New renewable energy tariff regulation for PV; carbon/emission incentive as add-on	Under new PV tariffs, the project is not feasible for IPPs, but becomes viable with an added ∼USD 10/tCO_2 emission incentive; for PLN, the same project is profitable due to de-dieselization cost savings and lower average generation cost.	Shows a misalignment between system-level value and investor returns; suggests redesigning tariffs/contracting to share avoided-cost benefits, and using carbon-linked incentives to close the bankability gap without undermining affordability.
Ref. [52]	Biomass power plant (BPP) case; Kundur Island, Riau; IPP vs PLN	New renewable energy tariffs for biomass (initial vs expansion tariff)	IPP feasibility differs sharply by tariff scenario (initial tariff positive NPV; expansion tariff can become negative, with feasibility requiring very high capacity factor); PLN perspective remains viable due to de-dieselization savings; large emissions reduction vs diesel is emphasized.	Implies tariffs should be grounded in avoided generation cost and operational realism; inclusive design should prevent tariff structures that push operational risk onto small/local IPPs while PLN captures system savings.
Ref. [45]	National household PV (34 provinces; 413-household empirical survey embedded in model)	Export tariff regulation for PV; PV investment incentives; environmental campaigns (and combinations)	Regulatory/incentive interventions increase intention, but intention does not always translate to adoption due to financial or facility constraints; combined policy packages (e.g., export tariff + incentives) perform better than single tools.	Highlights that "good" rules (e.g., export tariffs) fail without implementation capacity (supply-chain, installers, interconnection, information); inclusive policy mixes should integrate consumer protection, access mechanisms, and delivery infrastructure.

Refs.	Sample / policy locus	Regulatory instrument(s) assessed	Outcomes for RE scale-up (as reported)	Critical notes for inclusive regulatory design
Ref. [53]	National policy instrument (review/assessment)	Feed-in tariff (FIT) policy	Positions FIT as a widely used tool internationally to stimulate RE deployment and investment (evidence summarized at policy level).	FIT effectiveness depends on pricing logic, payment certainty, and grid access; inclusive FIT design must also address regional disparities and avoid regressive cross-subsidies that burden low-income consumers.
Ref. [54]	National energy-policy governance; comparative perspective	Fossil-fuel subsidy policy and reform trajectories	Argues that fossil-fuel subsidies and reform failures have hampered renewable energy development and transition, recommending more effective reform strategies informed by international comparison.	Frames subsidy reform as both technical and distributive: inclusive reform needs targeted protection for vulnerable groups and transparent sequencing so political feasibility does not stall RE policy progress.
Ref. [47]	National political economy; investment climate and household-scale RE	Subsidy regime and renewable policy signalling; rooftop solar rules (household ROI focus)	Finds that fossil dependence and subsidies slow transition; argues reform fears may be overstated with appropriate protection for low-income households; calls for stronger signalling to attract international investment and improve household ROI (e.g., rooftop solar rules).	Emphasizes credible, socially protected subsidy reform as an enabling condition for RE markets; connects inclusion to maintaining affordability and legitimacy while improving investor confidence and deployment speed.

Refs.	Sample / policy locus	Regulatory instrument(s) assessed	Outcomes for RE scale-up (as reported)	Critical notes for inclusive regulatory design
Ref. [55]	Environmental permitting and licensing as a cross-cutting gatekeeper for RE projects	Environmental approval / licensing policy; risk-based licensing; participation and transparency	Claims current implementation insufficiently reflects prudence/sustainability; recommends licensing reforms that align procedures with project risk, strengthen participation, protect vulnerable groups, and increase transparency using digital tools.	Shows that "streamlining" can undermine inclusion unless paired with procedural justice (participation), safeguards, and clear accountability; risk-based licensing must not become a pathway for exclusion or elite capture.
Ref. [56]	Palm-oil sector decarbonization via POME-to-power (biogas)	Sector-specific biogas power regulation (POME); just transition framing	Positions POME as a major RE opportunity but highlights regulatory/implementation challenges that complicate a just transition in the palm-oil sector.	Indicates a need for coherent rules spanning waste classification, grid interconnection, pricing/contracts, and benefit-sharing with communities near mills; inclusion requires avoiding "green" deployment that externalizes burdens to rural/plantation communities.
Ref. [57]	Small-scale/community-adjacent biogas digesters (agri/waste contexts)	Domestic and international regulatory limits for biogas empowerment	Argues empowerment is bounded by regulatory constraints that limit scalability and community control.	Shows that inclusive decentralization depends on regulatory flexibility that recognizes local governance practices while ensuring safety, grid access, and fair compensation.

Beyond tariffs, subsidy regimes and permitting systems conditions the political and social feasibility of regulatory reform. Analyses using energy justice frameworks show that fossil-fuel subsidies and reform failures have historically crowded out renewable energy and weakened transition credibility [54]. Political-economy evidence suggests that fears of subsidy reform backlash may be overstated when low-income households are explicitly protected, and that credible reform can improve both investor signalling and household-level renewable returns, particularly for rooftop solar [47]. In parallel, environmental licensing operates as a cross-cutting gatekeeper: current risk-based approval systems insufficiently integrate prudence, participation, and protection

of vulnerable groups, prompting calls for digital transparency and risk-proportionate procedures that do not trade speed for exclusion [55].

Sector-specific regulations further illustrate how inclusive outcomes hinge on regulatory coherence. In the palm-oil sector, biogas power from POME is identified as a major mitigation opportunity, yet fragmented rules on waste classification, grid access, and pricing constrain deployment and complicate a just transition [56]. At smaller scales, community-adjacent biogas digesters face regulatory limits that restrict empowerment despite alignment with local wisdom and decentralized energy goals [57]. Taken together, the evidence indicates that regulatory design in Indonesia must move beyond narrow efficiency or cost metrics toward integrated rule systems that align tariffs, subsidies, and permitting with distributive and procedural justice. Such an approach is essential to close deployment gaps, sustain affordability, and ensure that renewable energy scale-up contributes meaningfully to inclusive low-carbon development, as emphasized in earlier discussions of national targets, institutional capacity, and equity challenges [1,2,5].

4.4. Review of Findings: Institutional and Political Economy Constraints, PLN, Governance, and Justice Outcomes

The findings synthesized in Table 4 demonstrate that institutional and political economy constraints form a core barrier to Indonesia's renewable energy scale-up, reinforcing the slow annual increase of approximately 0.55% in renewable deployment reported at the national level [1]. Across the electricity sector, Ref. [58] identifies PLN's institutional logic, anchored in price stability and supply security, as a decisive bottleneck, where elite interests and collective conservatism systematically deprioritize renewable investments and the internalization of environmental externalities. This institutional inertia aligns with broader observations that fragmented governance and fossil-fuel dependencies undermine effective policy implementation [2,5].

Table 4: *Institutional and Political Economy Constraints: PLN, Governance, and Justice Outcomes*

Refs.	Discipline / domain	Methods / tools used	Key findings (institutional / political economy / justice)	Future directions / reforms suggested
Ref. [58]	Policy prioritization; energy transition strategy + mining/resource governance	Analytic Hierarchy Process (AHP) + sensitivity analysis	Stakeholder preferences prioritize energy transition over energy-related measures, mining governance, and resource transition; top-ranked alternatives emphasize national energy policy, electricity-sector reform, and energy infrastructure, while transparency, accountability, and permitting reforms dominate mining-governance priorities.	Use structured priority-setting to sequence reforms; integrate cross-sector trade-offs (electricity reform, infrastructure, incentives, licensing transparency) into implementable roadmaps.

Refs.	Discipline / domain	Methods / tools used	Key findings (institutional / political economy / justice)	Future directions / reforms suggested
Ref. [59]	Energy justice; infrastructure governance (WtE)	In-depth qualitative study (interviews, observations, focus groups) applying a multi-dimensional justice framework	Justice outcomes vary sharply across cases: Benowo aligns more closely with distributive, procedural, and recognition justice, while Putri Cempo remains fragmented and exclusionary; distributive justice is consistently weakest, with burdens borne by communities receiving minimal compensation.	Institutionalize participation; strengthen accountability and benefit-sharing; apply justice indicators ex-ante and ex-post in future WtE and transition projects.
Ref. [51]	Comparative political ecology; BRI governance; environmental justice	Systematic mapping of socio-environmental conflicts + grounded comparative analysis	Despite "green BRI" narratives, coal projects already planned or operating continue to generate environmental, health, and socio-economic harms; conflicts are shaped by power relations linking coal and nickel extractive industries, with sustained community and civil-society resistance.	Reform BRI governance using environmental-justice principles; incorporate local socio-political dynamics and "politics from below" into transition planning.
Ref. [60]	Political economy of critical minerals; industrial policy and distribution	Political economy analysis (conceptual + empirical narrative)	Nickel downstream industrialization creates "nationalist enclaves": rapid export and growth gains coexist with narrow networks of politically connected and foreign capital, while environmental and community externalities persist at extraction sites.	Embed equity and environmental safeguards in mineral industrialization; broaden benefit distribution; align critical-mineral governance with inclusive low-carbon development.
Ref. [61]	International economic law; trade governance of transition minerals	Legal analysis of WTO panel reasoning (Indonesia–Raw Materials dispute)	Reveals tension between developmental industrial policy (export restrictions for value addition) and WTO disciplines, exposing contradictory justifications and equity constraints for mineral-rich developing countries.	Design more responsive and equitable trade frameworks; preserve policy space for structural transformation while maintaining predictable trade governance.

Refs.	Discipline / domain	Methods / tools used	Key findings (institutional / political economy / justice)	Future directions / reforms suggested
Ref. [62]	Circular economy governance; EV ecosystem regulation	Qualitative analysis + interviews + benchmarking to global best practice	Indonesia's EV transition faces regulatory gaps in end-of-life (EoL) battery management; weak emphasis on EoL risks value leakage, while secondary markets and public awareness are critical for legitimacy and uptake.	Strengthen EoL-focused regulation; build secondary-market and collection systems; integrate public-awareness strategies into transition governance.
Ref. [50]	Macro-finance; sovereign risk and climate transition	Stock-flow consistent macroeconomic modelling (EIRIN) with decarbonization demand-shock scenarios	Trading-partner decarbonization spillovers can worsen balance-of-payments positions and raise public debt, increasing sovereign risk and constraining fiscal space for transition investment in Indonesia.	Coordinate climate and fiscal policy; manage stranded-asset and external-shock risks; design financing strategies that protect sovereign stability while enabling decarbonisation.
Ref. [47]	Political economy of subsidies; investment signalling; household-scale policy	Policy-economy analysis of subsidy dynamics	Fossil-fuel dependence and subsidies slow renewable deployment; subsidy reform can be politically feasible when combined with protections for low-income households; clearer policy signalling and improved rooftop-solar rules enhance household ROI and investor confidence.	Implement socially protected subsidy reform; strengthen regulatory clarity for investors; refine distributed-solar rules to raise household ROI without exacerbating inequality.

Complementing this diagnosis, AHP-based prioritization analysis used by [58] reveals that stakeholders consistently rank electricity-sector reform, national energy policy, and infrastructure development as top transition priorities, quantitatively outweighing narrower sectoral interventions. The prominence of transparency, accountability, and permitting reforms within mining governance underscores how administrative design and sequencing of reforms condition the feasibility of broader low-carbon pathways. These findings resonate with earlier evidence that inadequate regulatory frameworks and local capacity gaps weaken Indonesia's renewable energy ambitions [3, 36].

Justice-oriented analyses further expose the distributive consequences of institutional choices. Ref. [59] shows that even where regulatory commitments to justice exist, implementation gaps persist in waste-to-energy initiatives, distributive justice remains the weakest dimension, with communities bearing environmental and social burdens while receiving limited compensation or participation. Similarly, ref. [51] documents how coal projects linked to China's Belt and Road Initiative continue to generate health and livelihood impacts despite "green BRI" narratives,

reflecting power asymmetries that marginalize local voices. These dynamics reinforce concerns that renewable and transition infrastructures can reproduce inequality if procedural and recognition justice are not embedded in governance design [8,9].

At the macro-political economy level, persistent coal lock-in is explained by aligned domestic and international incentives. Ref. [60] shows how Indonesia's nickel down streaming strategy produces enclave-style development, concentrating benefits among politically connected actors while externalizing environmental costs to extraction communities. Ref. [61]'s legal analysis adds an external constraint, highlighting how WTO disciplines limit policy space for mineral-rich countries seeking inclusive, value-adding industrialization within the energy transition.

Emerging transition sectors introduce additional governance challenges. Ref. [62] finds that Indonesia's electric-vehicle ambitions are undermined by insufficient regulation of battery end-of-life management, risking environmental harm and missed opportunities for secondary value creation. At the same time, Ref. [50] quantitatively models how international decarbonization spillovers can heighten sovereign risk through balance-of-payments pressures and rising public debt, constraining fiscal capacity for transition investment. These macro-financial constraints intersect with subsidy politics analyzed by [47], who argue that socially protected subsidy reform and improved rooftop-solar rules can simultaneously enhance household-level returns and investor confidence without exacerbating inequality.

Taken together, the evidence in Table 4 underscores that Indonesia's renewable energy transition is not primarily constrained by technological readiness, but by entrenched institutional incentives, political economy lock-ins, and uneven justice outcomes. Addressing these constraints requires coordinated reform of PLN's mandate and incentives, transparent and sequenced governance reforms across energy and extractive sectors, and explicit integration of distributive, procedural, and recognition justice into transition policy design. Without such reforms, the pursuit of inclusive low-carbon development risks remaining aspirational rather than transformative.

5. Discussions

This review demonstrates that Indonesia's renewable energy transition cannot be understood through isolated perspectives of technology, finance, regulation, or community participation. Across the reviewed studies, renewable energy deployment is shaped by the interaction between institutional arrangements, investment incentives, political-economic interests, and justice considerations. The findings therefore suggest that the transition is not simply a process of replacing fossil-fuel technologies with renewable alternatives, but an institutional transformation involving changes in authority, market access, investment incentives, and the distribution of transition benefits and burdens.

5.1. From Fragmented Barriers to an Integrated Transition Framework

The findings related to community adoption, financing, and regulatory design indicate that these dimensions are mutually dependent. Studies on community participation show that trust, procedural justice, local capacity, and stakeholder engagement influence the acceptance and continuity of renewable energy initiatives [8,15,16]. Financing studies demonstrate that bankability depends on predictable tariffs, offtake arrangements, risk allocation, and government-backed incentives [44–48]. At the institutional level, regulatory fragmentation and the dominant role of PLN constrain the ability of renewable-energy projects, particularly decentralized and community-based initiatives, to access markets and infrastructure [16,17,58].

These findings suggest that inclusion, bankability, and regulatory credibility should not be treated as separate policy objectives. Weak regulatory credibility can increase investment risk, which limits financing and consequently restricts opportunities for community participation. Conversely, limited participation can weaken local legitimacy and create implementation risks, which may further reduce the attractiveness of projects to investors. The three dimensions therefore form an interconnected institutional configuration rather than a sequence of independent barriers.

This interpretation extends the multi-level perspective (MLP) by emphasizing that regime resistance is not limited to technological or market inertia. In Indonesia, regime stability is reproduced through institutional mandates, pricing arrangements, procurement rules, and organizational incentives that shape the opportunities available to renewable-energy actors. PLN's dominant position illustrates this tension. As the central electricity utility, PLN performs important functions related to affordability and system reliability, but its institutional position can also constrain the market space available to decentralized and community-based alternatives. Thus, the transition challenge is not simply whether renewable technologies are technically available, but whether existing institutions can accommodate new actors and redistribute access to markets, infrastructure, and decision-making.

From this perspective, governance is not merely an enabling condition for renewable-energy deployment. Governance determines the institutional space within which transition actors can operate. Regulatory design, grid access, procurement, licensing, and participation mechanisms determine who can enter the energy system, under what conditions, and with what capacity to influence transition outcomes.

5.2. Bankability as an Institutional and Political-Economic Outcome

The review further indicates that renewable-energy bankability should not be understood as an intrinsic characteristic of a technology or project. Instead, bankability is institutionally and politically constructed through tariffs, procurement arrangements, subsidies, risk allocation, and the distribution of system-level benefits.

The Nias solar case provides a particularly clear illustration. A 26 MW solar project was financially unattractive to independent power producers under existing tariff arrangements but became highly profitable for PLN because the utility could capture the avoided costs associated with diesel generation [44]. This difference demonstrates that the economic value of renewable energy and the financial return available to a particular investor are not necessarily equivalent. The problem therefore concerns not only project economics, but also the institutional mechanisms through which system-level benefits are allocated among actors.

Similar mechanisms are evident in other reviewed studies. Rooftop photovoltaic adoption is influenced by financial and institutional constraints even when households express willingness to adopt the technology [45]. Geothermal development faces exploration risk, high upfront costs, and uncertainty surrounding tariffs and power purchase agreements [46]. Foreign investment can support renewable deployment but may also generate macro-financial risks when transition-related capital flows interact with sovereign debt and balance-of-payments pressures [48,50]. At the same time, fossil-fuel subsidies and continued coal financing distort relative investment incentives and reinforce incumbent energy pathways [47,51].

These findings provide a broader political-economic interpretation of bankability. Investment decisions are shaped by who captures benefits, who bears risks, and which benefits are recognized within market rules. Bankability is therefore partly a political-economic outcome. Regulatory reform should consequently not be viewed only as an effort to improve market efficiency. It also redistributes economic opportunities and risks among state utilities, private investors, governments,

households, and communities.

The Indonesian experience therefore suggests that improving renewable-energy bankability requires more than reducing project-level financial risk. It requires institutional arrangements capable of translating system-level benefits into investable returns while preventing transition costs from being disproportionately transferred to households and vulnerable communities.

5.3. Energy Justice as a Governance Outcome

The review also shows that renewable-energy deployment does not automatically produce a just transition. Justice outcomes depend on governance arrangements that determine how benefits and burdens are distributed, who participates in decision-making, and whose interests are recognized. The reviewed studies identify distributive, procedural, and recognition dimensions as important components of energy justice [8, 9, 28, 29].

The evidence concerning waste-to-energy initiatives is particularly relevant. Although regulatory commitments to justice may exist, implementation gaps can leave communities bearing environmental and social burdens while receiving limited compensation or participation [59]. Similarly, evidence concerning coal-related development associated with the Belt and Road Initiative illustrates how local health and livelihood impacts can persist despite broader narratives of sustainable or green development [51]. These findings suggest that low-carbon or transition-oriented infrastructure can reproduce existing inequalities when procedural and recognition dimensions of justice are not embedded in governance arrangements.

This has an important implication for the interpretation of community participation. Participation should not be treated merely as an instrument for increasing project acceptance. Participation is itself a dimension of justice, because it determines whether affected communities have meaningful influence over decisions concerning their livelihoods, environments, and access to energy resources. Likewise, community ownership and benefit-sharing should be understood not only as mechanisms for improving adoption but also as institutional mechanisms for redistributing the economic value created by renewable-energy development.

The political-economic dimension reinforces this argument. The reviewed evidence on Indonesia's nickel down streaming strategy shows how transition-related industrial development can concentrate economic benefits among politically connected actors while externalizing environmental costs to extraction communities [60]. This indicates that decarbonization can coexist with persistent distributive inequality when the underlying structures of ownership, political influence, and resource governance remain unchanged.

Thus, the review suggests that energy justice is partly a governance outcome. Distributive, procedural, and recognition justice are shaped by the institutional rules through which transition decisions are made and benefits and burdens are allocated. Justice should therefore be embedded ex ante in the design of tariffs, licensing, procurement, financing, and ownership arrangements rather than evaluated only after projects have been implemented.

5.4. Indonesia in Comparative Perspective

Although the evidence synthesized in this review is primarily focused on Indonesia, comparison with selected studies from other emerging and developing economies indicates that Indonesia's transition challenges are neither entirely unique nor fully transferable. Regulatory uncertainty, limited financing, fossil-fuel dependence, and institutional capacity constraints are also reported across other developing contexts [5, 15, 33, 48]. However, Indonesia combines these general challenges with distinctive institutional characteristics, including the dominant role of PLN, its

geographically dispersed electricity system, persistent fossil-fuel dependence, and substantial regional disparities.

The comparison with Vietnam illustrates this distinction. Both Indonesia and Vietnam face challenges in creating regulatory conditions capable of attracting renewable-energy investment, but differences in investment policies and regulatory arrangements influence the incentives available to investors [3]. Evidence from ASEAN similarly indicates that renewable-energy investment depends on policy credibility, market design, and the ability of governments to reduce investment risks [6]. Comparative evidence on feed-in tariff policies further suggests that the effectiveness of renewable-energy incentives depends on how tariff design interacts with investment conditions, grid access, and institutional arrangements [33,53].

These comparisons suggest that similar policy instruments can generate different outcomes because their effectiveness is mediated by national institutional structures and political-economic relationships. PLN's particular institutional position is specific to Indonesia, as are aspects of the country's electricity-market structure and geographical configuration. However, the underlying mechanisms through which incumbent power, regulatory credibility, investment-risk allocation, and unequal participation shape transition outcomes are relevant to other emerging economies.

The analytical value of the Indonesian case therefore lies not in its exceptionalism, but in its ability to reveal how general transition mechanisms operate within a particular institutional configuration. This distinction is important for international scholarship because it allows Indonesia-specific characteristics to be separated from mechanisms that may be transferable across different low-carbon transition contexts.

5.5. An Integrated Policy and Research Agenda

In response to RQ4, the reviewed evidence indicates that an effective policy and research agenda should align inclusion, bankability, and regulatory credibility rather than address them as separate policy domains. Inclusion requires meaningful participation, community capacity, and mechanisms for benefit-sharing. Bankability requires predictable revenue arrangements, appropriate risk allocation, and targeted de-risking mechanisms. Regulatory credibility requires coherent procurement, tariff, licensing, and grid-access arrangements.

Importantly, these dimensions are mutually reinforcing. Regulatory credibility can reduce investment uncertainty and improve bankability, while inclusive governance can strengthen local legitimacy and reduce implementation risks. Conversely, weak participation, uncertain regulation, and poorly allocated financial risks can reinforce one another and prevent renewable projects from reaching scale. The integrated agenda therefore requires coordination across financial, regulatory, and social dimensions of the transition.

The research agenda should consequently move beyond examining these dimensions independently. Future studies should investigate how specific regulatory reforms influence financing outcomes, how financing structures affect distributive and procedural justice, and how community participation influences project bankability and long-term legitimacy. Comparative research across emerging economies would also help distinguish context-specific institutional arrangements from more general mechanisms of incumbent power, investment risk, and energy justice.

5.6. Theoretical Implications

Taken together, the review generates three broader theoretical implications. First, governance determines the institutional space available for renewable-energy transitions by allocating decision-making authority, market access, and participation opportunities. Second, political economy

shapes the bankability and distributional consequences of low-carbon transitions because subsidies, tariffs, investment rules, and institutional power determine how risks, rents, and benefits are allocated. Third, energy justice is a governance outcome because distributive, procedural, and recognition outcomes depend on the institutional arrangements through which transition decisions are made.

These relationships can be conceptualized as a governance–political economy–justice nexus. Governance shapes who have authority and access; political-economic arrangements shape the distribution of risks and benefits; and these distributions determine whether transition outcomes are socially just. The Indonesian case therefore demonstrates that an inclusive low-carbon transition requires not only technological substitution, but also changes in governance structures, political-economic incentives, and institutional mechanisms of participation and benefit distribution.

6. Conclusion

This systematic literature review examined the institutional, financial, governance, and justice dimensions of Indonesia's renewable energy transition. The findings indicate that the principal constraints are not primarily related to technological potential, but to the institutional and political-economic structures through which renewable energy is financed, regulated, deployed, and governed. Renewable-energy transition should therefore be understood not simply as technological substitution, but as an institutional transformation involving changes in authority, market access, investment incentives, and the distribution of transition benefits and burdens.

The review generates three theoretical contributions. First, it demonstrates that governance determines the institutional space available for renewable-energy transition. Regulatory design, grid access, procurement, licensing, and institutional mandates influence which actors can participate and how effectively renewable-energy alternatives can challenge established energy regimes. The Indonesian case, particularly the dominant role of PLN, illustrates how institutional concentration can simultaneously support system stability while constraining decentralized and community-based alternatives.

Second, the review shows that renewable-energy bankability is an institutional and political-economic outcome. Tariffs, subsidies, procurement arrangements, risk allocation, and the distribution of system-level benefits influence which projects and actors become financially viable. The divergence between the financial attractiveness of renewable projects to PLN and to independent power producers illustrates that project viability depends partly on how institutional arrangements allocate costs, risks, and benefits. Political economy is therefore essential for understanding the persistence of incumbent energy pathways and the uneven distribution of transition opportunities.

Third, the review establishes that energy justice is a governance outcome rather than an automatic consequence of decarbonization. Distributive, procedural, and recognition justice depend on how transition institutions allocate benefits and burdens, provide opportunities for participation, and recognize affected communities. Renewable-energy deployment can therefore remain socially inequitable when low-carbon infrastructure is introduced without corresponding changes in participation, ownership, benefit-sharing, and recognition.

In response to the fourth research question, the review indicates that an integrated policy and research agenda should align inclusion, bankability, and regulatory credibility. These dimensions are interdependent: credible regulation can reduce investment risk, inclusive governance can strengthen legitimacy and implementation, and appropriate financing mechanisms can enable broader participation. Their alignment therefore requires coordinated institutional reform rather than isolated policy interventions.

Finally, although PLN's institutional role, Indonesia's electricity-market structure, and its

geographical configuration are context-specific, the underlying mechanisms identified in this review (incumbent power, regulatory credibility, investment-risk allocation, unequal participation, and distribution of transition benefits) have broader relevance to emerging and developing economies. The review consequently proposes a governance–political economy–justice nexus as a useful analytical lens for understanding inclusive low-carbon transitions beyond Indonesia. This perspective highlights that achieving a just transition requires simultaneous attention to who governs the transition, who captures its economic benefits, who bears its risks, and whose voices are recognized in shaping its future.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors use ChatGPT in order to improve academic language quality, clarity, and coherence of the manuscript, including grammar, sentence structure, readability, and clarity. After using this tool/service, the authors review and revise the content as needed and take full responsibility for the content of the published article.

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