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Research Paper

Emission Trading Systems in Indonesia's Power Generation Sub-Sector: Comparative Analysis, Governance Failures, and Policy Recommendations

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ABSTRACT - Indonesia's Emission Trading System (ETS) for the power generation sub-sector is a central instrument for achieving its Nationally Determined Contribution (NDC) targets, yet critical governance failures undermine its environmental and fiscal effectiveness. A significant gap in the existing literature concerns how long-term contractual provisions in power markets interact with ETS compliance obligations, and whether those interactions systematically undermine the polluter-pays principle. This study employs a qualitative multi-method design combining comparative institutional analysis of ETS frameworks in the European Union, China, and Indonesia with primary data from an expert Focus Group Discussion (FGD) of six informants, coded using NVivo 12 qualitative software. The study identifies two structural governance failures. First, the ETS is operationally voluntary: the penalty regulation mandated by Law No. 7/2021 has not been issued by the Ministry of Finance, eliminating the compliance incentive. Second, a Government Force Majeure (GFM) clause embedded in Power Purchase Agreements (PPAs) between the state utility PT PLN and Independent Power Producers (IPPs) creates a multi-stage fiscal pathway through which ETS compliance costs may be transferred from coal-fired power plant operators to the state energy subsidy budget — structurally inverting the polluter-pays principle. Comparative analysis further reveals that while Indonesia's intensity-based ETS shares design features with China's national carbon market, it lacks the enforcement architecture that China has progressively established. The study contributes a novel governance failure mode — the GFM–ETS fiscal compensation pathway — not previously theorised in ETS governance literature, and recommends enforcement regulation issuance, GFM–subsidy fiscal interface reform, integrated MRV platform development, bottom-up cap-setting anchored in plant-level data, and establishment of a dedicated carbon market authority.

Keywords: emission trading system, carbon pricing, government force majeure, power purchase agreement, polluter-pays principle, PTBAE-PU, enforcement failure, fiscal sustainability, energy transition, Indonesia

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INTRODUCTION

The power generation sector is central to Indonesia's climate transition challenge. With fossil -fuel-based plants accounting for approximately 85 percent of 101 GW installed capacity at end-2024 — the majority of which are coal-fired power plants (CFPP) — the sub-sector is among the country's largest sources of greenhouse gas (GHG) emissions (MEMR 2025). Under the enhanced nationally determined contribution (ENDC), Indonesia has committed to reducing GHG emissions by 31.89 percent unconditionally and 43.2 percent with international support against a business-as-usual baseline by 2030, with a net-zero target by 2060 or earlier (KLHK 2022). Effective carbon pricing in the power generation sub-sector is therefore a structural precondition for NDC delivery. Indonesia operationalised this imperative through a phased Emission Trading System (ETS) for the power generation sub-sector established under the Ministry of Energy and Mineral Resources (MEMR) Regulation No. 16/2022, within the Carbon Economic Value (Nilai Ekonomi Karbon — NEK) framework of Presidential Regulation No. 98/2021 (revised by Presidential Regulation No. 110/2025). Each participating plant receives an emission allowance, which also serves as the cap — the Technical Approval of Upper Emission Limit for Business Actors (PTBAE-PU) — set against a progressively tightening intensity benchmark (tCO_2e/MWh). Compliance can be achieved through emission reductions, PTBAE-PU trading, or the purchase of Emission Reduction Certificates (SPE).

Despite this architecture, two structural governance failures place the system's environmental and fiscal effectiveness in question. The first is the absence of enforcement. The penalty regulation mandated by Law No. 7/2021 — the statutory instrument that would impose financial consequences for PTBAE-PU non-compliance — has not been issued by the Ministry of Finance (MoF). Without a credible penalty, the ETS cannot generate a price signal sufficient to drive low-carbon investment, rendering the system operationally voluntary regardless of how sophisticated its upstream regulatory design is. The second failure is more analytically novel and constitutes the primary focus of this study. Independent power producers (IPPs) supplying electricity to the state utility PT PLN (Persero) operate under long-term power purchase agreements (PPAs) containing a government force majeure (GFM) clause — a cost-recovery provision triggered when a new government regulation increases operators' costs following contract execution. Given that ETS compliance obligations arose after existing PPAs were signed, they potentially qualify as GFM-triggered costs, creating a fiscal pathway through which compliance costs may be transferred from CFPP operators to PLN and, ultimately, to the state energy subsidy budget. This mechanism structurally inverts the polluter-pays principle: the more ambitious the PTBAE-PU tightening pursued in the name of NDC targets, the greater the potential state fiscal exposure.

International scholarship on ETS governance has addressed regulatory design (ICAP 2016; 2024), MRV system integrity (Deng et al., 2018; Yu & Lo 2014), cap-setting methodologies (Pang & Duan 2016; Goulder et al., 2019), and fossil fuel subsidy interactions with carbon pricing (Bassi et al., 2023; Li & Sun 2018). For developing -economy contexts, Heggelund et al. (2022) demonstrate the institutional case for intensity-

based implementation, while Wang et al. (2019) and Li et al. (2022) identify enforcement weakness and MRV capacity as jointly determinative of effectiveness in China's national ETS. No existing study has theorised how long-term contractual GFM provisions in state-contracted power markets can systematically transfer ETS compliance costs from emitters to the state budget. This gap — extending beyond Indonesia to any developing economy where fossil fuel electricity generation is governed by PPAs with cost-recovery provisions — constitutes the theoretical problem and the primary contribution of this study.

Three research questions organise the analysis. RQ1: How does the governance architecture of Indonesia's power sector ETS compare with the EU ETS and China's national ETS? RQ2: What are the fiscal implications of PTBAE-PU tightening under the GFM–PPA–subsidy contractual framework? RQ3: What governance reforms and cap-setting approaches are most appropriate for Indonesia's energy transition context? The study employs a qualitative multi-method design — combining comparative institutional analysis with NVivo-coded FGD primary data — interpreted through the three analytical frameworks developed in theoretical framework.

Theoretical framework

This study integrates three analytical frameworks selected for their direct analytical traction on the institutional and contractual failures identified in the research problem: Externality Theory and the polluter-pays principle; Carbon Economic Value and ETS Design; and Energy Transition Theory and Regulatory Completeness. The frameworks are applied cross-sectionally throughout the analysis, with each illuminating a distinct dimension of the governance problem.

Externality theory and the polluter-pays principle

Externality theory, formalised by Pigou (1920), establishes that when private production generates social costs not reflected in market prices, a corrective instrument set equal to the marginal external cost can restore allocative efficiency. GHG emissions from fossil fuel combustion constitute the canonical large-scale negative externality: third parties — who bear no responsibility for these emissions — are subjected to costs through climate damage, air pollution, and health impacts (Stern, 2006). In electricity markets, the Marginal Social Cost of CFPP-generated electricity exceeds the Marginal Private Cost by the marginal external cost, inducing overproduction relative to the social optimum.

Carbon pricing through ETS operationalises the polluter-pays principle by creating a property right structure (PTBAE-PU) and a market mechanism to internalise GHG externalities. The foundational normative claim is that emission permit costs must be borne by the polluting entity — not by the state, the utility, or the consumer. This principle is the benchmark against which the GFM–ETS fiscal compensation pathway identified in this study represents a structural inversion.

Government externality theory (Trantidis 2023) adds a critical dimension: poorly designed regulatory interventions can themselves generate new externalities through institutional bias and inadequate enforcement design. The GFM–ETS pathway represents precisely such a government-induced externality: by failing to address the contractual interface between ETS and existing PPAs, the regulatory architecture may systematically transfer compliance costs from emitters to the state, contradicting the polluter-pays principle that it was designed to enforce. This framework provides the core theoretical basis for RQ2.

Hahn and Stavins (2010) further demonstrate that ETS efficiency requires properly functioning markets; this condition is violated when enforcement is absent. Kettner et al. (2008) document how over-allocation in the EU ETS Phase 1 undermined price signals, directly informing the Indonesian context of benchmarks set without adequate MRV or enforcement foundations. Grubb and Neuhoff (2006) show that excessive free allocation generates windfall profits without driving decarbonisation — a finding directly applicable to Indonesia's current 100-percent free allocation design.

Carbon economic value and ETS design

Carbon Economic Value (Nilai Ekonomi Karbon — NEK) encompasses multiple instruments for internalising GHG externalities,

including ETS, carbon taxes, result-based payments, and crediting mechanisms (Presidential Regulation No. 98/2021; ICAP, 2016). ETS operates through two principal design archetypes. Under cap-and-trade systems (as in the EU ETS), an absolute emission cap declines over time with permits allocated through free distribution or auctioning; the market determines the carbon price. Under baseline-and-credit systems, emission intensity benchmarks (tCO_2/MWh) are set per plant based on technology and capacity class; plants emitting below the benchmark generate surplus permits that may be sold, while those emitting above the benchmark must purchase permits or carbon credits.

ICAP (2016) identifies the fundamental design trade-off in intensity-based systems: more ambitious benchmarks create scarcity, raise permit prices, and incentivise low-carbon investment, but also increase compliance costs that — in Indonesia's contractual context — can be transferred to the state through the GFM mechanism. The materiality of carbon pricing as an operator cost burden is empirically demonstrated across Indonesia's energy sector: techno-economic modelling in the upstream oil and gas context shows that carbon tax imposition increases unit production costs, reduces the optimal production rate, and shortens the economic production life of an oil field as operators reach the economic cut-off point earlier (Aladar et al., 2026). The design of PTBAE-PU allocation and tightening schedules is therefore not merely a technical question of emission reduction ambition but carries direct fiscal implications for the national budget. This framework provides the analytical basis for comparing ETS architectures in RQ1 and evaluating cap-setting options in RQ3.

Energy transition theory and regulatory completeness

Energy Transition Theory describes the systemic shift from fossil-fuel-based to low-carbon energy systems, encompassing technological, economic, policy, and socioeconomic dimensions (IEA 2024). For carbon pricing instruments to function as intended energy transition levers, the theory identifies stable, long-term regulatory frameworks providing investment certainty as a foundational enabling condition. Without credible enforcement, a carbon price signal cannot be sustained, and investment decisions in low-carbon technology cannot be grounded in a durable policy framework.

This framework applies directly to Indonesia's ETS context: the non-issuance of the carbon tax enforcement regulation under Law No. 7/2021 constitutes a failure of the regulatory stability condition. Hickel and Kallis (2020) caution that structural decoupling of economic growth from emissions requires institutional completeness — a credible enforcement mechanism, a functional carbon price signal, and the elimination of perverse fiscal incentives. Without these, ETS risks functioning as an accounting exercise rather than a behavioural instrument. This framework provides the theoretical basis for assessing the systemic character of Indonesia's governance gaps and for interpreting the FGD findings on governance node completeness, directly addressing RQ3.

Prior research and the research Gap

Prior research on ETS governance has examined regulatory design frameworks (ICAP 2016; 2024), MRV system effectiveness (Deng et al., 2018; Yu & Lo 2014), cap-setting methodologies (Pang & Duan, 2016; Goulder et al., 2019), and interactions between fossil fuel subsidies and carbon pricing effectiveness (Bassi et al., 2023; Li & Sun 2018). For developing-economy contexts, Li et al. (2022) demonstrate that programme design, industry risk characteristics, and MRV capacity are jointly determinant of ETS effectiveness in China's pilots. Wang et al. (2019) identify data quality, enforcement capacity, and institutional coordination as key challenges. Heggelund et al. (2022) find that gradual intensity-based implementation provides a more politically sustainable pathway in fossil-fuel-dependent economies.

A critical gap in this literature is the absence of analysis addressing the specific intersection of long-term contractual GFM provisions and ETS compliance obligations in state-contracted power markets — the central empirical contribution of this study. No existing work has theorised how PPA contractual structures can systematically transfer ETS compliance costs from emitters to state budgets, nor assessed the implications for the environmental

effectiveness and fiscal sustainability of carbon pricing in emerging economies.

METHODOLOGY

Research design

This study employs a qualitative multi-method design integrating three complementary components: 1). structured comparative institutional analysis of ETS governance across the EU, China, and Indonesia; 2). systematic secondary data analysis of Indonesia's power sector emission profile, energy subsidy framework, and PTBAE-PU implementation record; and 3). primary data collection through an expert focus group discussion (FGD), analysed using NVivo 12 qualitative software.

The multi-method design is motivated by the specific requirements of the three research questions rather than by a general preference for qualitative approaches. RQ1 — governance architecture comparison — requires cross-system institutional analysis of rules, enforcement structures, and fiscal mechanisms that cannot be reduced to quantitative indices without loss of institutional meaning. RQ2 — fiscal implications of PTBAE-PU tightening — requires integration of legal document analysis, regulatory fiscal data, and expert interpretation of contractual mechanisms that operate through institutional rather than market channels. RQ3 — governance reform options — requires interpretive synthesis of comparative evidence and stakeholder knowledge not accessible through secondary data alone. The design enabled triangulation across three distinct data source types: documentary and regulatory sources established the institutional architecture; statistical and fiscal data provided quantitative evidence of implementation status; and primary FGD data provided expert interpretation of causal mechanisms and reform feasibility. Where findings converged across these sources, analytical confidence was strengthened; divergences were examined and reported where they occurred (Creswell 2009; Bandur 2019).

Comparative institutional analysis framework

The comparative analysis examines ETS governance across eight analytical dimensions, selected to capture the full institutional chain from regulatory design to market outcome and fiscal consequence: 1). operational coverage and sectoral scope; 2). cap type and stringency trajectory; 3). allowance allocation methodology; 4). MRV system architecture and verification requirements; 5). enforcement mechanism and penalty structure; 6). carbon price signal and market liquidity; 7). revenue generation and use; and 8). fiscal integration risk and subsidy interaction. These dimensions correspond to the governance nodes examined under RQ1 and are consistent with the ICAP comparative ETS assessment methodology (ICAP 2024).

Case selection followed a structured rationale. The EU ETS was selected as the reference benchmark because it is the longest operating, most extensively documented multi-sector carbon market globally, providing the institutional standard against which design maturity, enforcement architecture, and price signal effectiveness are most rigorously assessed (ICAP 2024; Grubb & Neuhoff 2006). China's national ETS was selected as the primary comparator because it shares three structural features directly relevant to Indonesia's governance problem: intensity-based benchmarking as the cap mechanism; concentration in the power sector as the initial coverage scope; and state-mediated electricity supply in a fossil-fuel-dominant grid. These features make China's institutional trajectory — particularly its progressive MRV reforms and 2024 enforcement strengthening — directly instructive for diagnosing Indonesia's governance gaps. Systems in South Korea, Australia, and California were reviewed but excluded: their absolute cap designs, deregulated electricity market structures, and mature institutional enforcement capacity differ sufficiently from Indonesia's context to limit direct comparative inference for the specific GFM–fiscal problem this study addresses.

Comparative analysis was conducted through a systematic documentary review. For each system, primary regulatory instruments and official institutional reports were coded against the eight dimensions using a structured comparison matrix. Differences across systems were assessed for their analytical relevance to Indonesia's governance architecture and the GFM–ETS fiscal pathway documented in Section 4.4.

Document selection: criteria and procedure

Secondary documentary sources were identified through a two-stage procedure governed by explicit inclusion and exclusion criteria. In the first stage, Indonesian regulatory and statistical documents were selected on the basis of direct legal authority over CFPP ETS design and implementation. The inclusion criterion required a document to constitute either a primary legal instrument governing PTBAE-PU allocation, compliance, enforcement, or fiscal treatment, or an official statistical source providing primary quantitative data on the research variables. All instruments meeting this criterion were included: MEMR Regulation No. 16/2022 (ETS operational framework); Presidential Regulation No. 98/2021 as revised by Presidential Regulation No. 110/2025 (NEK framework); Law No. 7/2021 (statutory enforcement mandate); and Ministry of Finance Regulations No. 174/2019, No. 178/2021, and No. 20/2025.

The three MoF regulations are treated as primary analytical sources — not background references — because the allowable or non-allowable cost classification they govern is the mechanism through which ETS compliance costs may enter the state subsidy budget, as documented in Section 4.4. Documents superseded without a transitional effect or outside the direct PTBAE-PU regulatory chain were excluded. Official statistical sources included PLN Statistical Reports (2021–2024), ESDM annual energy statistics, KLHK's ENDC (2022), and RUKN 2025 (MEMR Decree No. 85/2025). The 2021–2024 range covers the pre-mandatory ETS baseline (2021–2022) and Phase 1 mandatory implementation (2023–2024).

In the second stage, international comparative and peer-reviewed sources were identified through targeted searches of Google Scholar and Scopus using the terms "Emission Trading System governance", "carbon pricing developing economies", "China ETS enforcement", "EU ETS cap-setting", "intensity-based carbon market", and "fossil fuel subsidy carbon pricing interaction". Searches were restricted to publications from 2005 onwards. International institutional reports were included based on institutional authority and data comprehensiveness. Sources were excluded where they predated operational ETS implementation in the relevant jurisdiction or did not contain primary empirical content relevant to the eight analytical dimensions.

FGD data collection

The FGD was conducted on 5 February 2025, online, from 08:00 to 12:00 WIB. Six expert informants provided primary data through structured presentations followed by facilitated discussion; a further 25 participants attended in an observational capacity and did not contribute primary data to the analysis. Informant selection followed purposive expert sampling targeting individuals with direct institutional responsibility for the specific regulatory, contractual, and fiscal mechanisms under examination — not general familiarity with climate policy (Hennink et al., 2020). Regulators were selected for direct authority over PTBAE-PU design and fiscal subsidy calculation; the PLN executive for direct operational responsibility for PPA administration and GFM clause management; the IPP association representative for direct contractual exposure to PTBAE-PU compliance obligations; and the academic and think-tank informants for specialised expertise in comparative carbon market governance (Table 1).

The six-informant sample constitutes a recognised methodological limitation. Expert purposive sampling is appropriate for governance research in which the institutional population with direct knowledge of the PTBAE-PU mechanism is narrow, but convergence frequencies reported in Section 4.5 — 84% and 72% — represent five of six and four of six individuals, respectively, and should be interpreted as indicators of cross-expert convergence rather than statistically generalisable prevalences. This limitation is partially mitigated by the triangulation design: FGD findings are cross validated against documentary and secondary data sources throughout the analysis.

Secondary data analytical process

Secondary data were analysed through a structured three-stage process aligned with the research questions. Stage 1 — Emission profile and PTBAE-PU trend analysis (addressing RQ1 and RQ2). Installed capacity, emission intensity, and PTBAE-PU participation data were extracted

Table 1. FGD informant profile and categorisation

Category	Informant and institution	Key expertise relevant to research
Regulator (2)	Ir. Jisman P. Hutajulu, M.M. – Director General of Electricity, ESDM; Wahyu Utomo, S.Sos. M.Si. – Head of Budget Policy Center, Fiscal Policy Agency, Ministry of Finance	PTBAE-PU regulation design; MRV system; carbon tax mandate; subsidy calculation under MoF Regulation 174/2019
Operator (1)	Anonymous – Executive Vice President, PT PLN (Persero)	PLN Climate Click digital platform; PLN–IPP PPA dynamics; GFM clause implications; intra-group permit trading
Industry Association (1)	Arthur Simatupang – Chairman, Indonesian Independent Power Producers Association (APLSI)	IPP cost structure; PPA compliance mechanisms; investment climate; APLSI policy proposals
Academic / Think Tank (2)	Moekti H. Soejachmoen – Executive Director, IRID (Indonesia Research Institute for Decarbonization); Dr. Surya Darma, MBA – Independent Energy Expert	Carbon pricing mechanisms; EU and China ETS comparative analysis; energy technology transition

Source: Authors (2025). FGD conducted on 5 February 2025, online.

from PLN Statistical Reports (2021–2024) and ESDM annual statistics and organised into a time-series dataset covering the pre-mandatory ETS baseline and Phase 1 mandatory implementation period. Participation rates (99 units in 2023; 146 units in 2024) were cross-checked against MEMR Regulation No. 16/2022 phase specifications. The RUKN 2025 projected emission peak and net-zero trajectory were used as the reference scenario against which Phase 1 intensity trends were assessed.

Stage 2 — Fiscal pathway analysis (addressing RQ2). The GFM–ETS fiscal compensation pathway was constructed by systematically cross-referencing: standard PLN–IPP PPA GFM clause language; MEMR Regulation No. 16/2022 establishing PTBAE -PU as a post-PPA government obligation; and MoF Regulations No. 174/2019, No. 178/2021, and No. 20/2025 governing the subsidy COGS formula and allowable cost classification. The analytical procedure determined, for each stage of potential GFM activation, which regulatory instrument governed the classification decision and what the fiscal consequence would be under each outcome. FGD testimony from the MoF Fiscal Policy Agency informant and the MEMR Director General validated this documentary analysis against direct regulatory experience, constituting the primary triangulation point between secondary data and primary qualitative findings.

Stage 3 — Comparative architecture coding (addressing RQ1). EU ETS and China national ETS design parameters were extracted from ICAP 2024 reports, European Commission documentation, and World Bank Carbon Pricing Dashboard 2024, entered into the eight-dimension comparison matrix, and coded against the same dimensions applied to Indonesia's ETS data.

NVivo analytical methods

FGD transcripts (six total, one per informant) were processed in NVivo using five sequential analytical techniques: 1). hierarchical node analysis — coding frequency and source coverage across all transcripts to identify dominant governance themes; 2). matrix coding — mapping intersections between governance nodes and research themes; 3). comparative case diagrams — visualising convergences and divergences between Regulator, Operator, Association, and Academic perspectives; 4). causal coding — mapping cause-effect relationships, particularly the GFM–ETS fiscal pathway; and 5). concept mapping — constructing the integrated governance architecture linking regulatory, technological, contractual, and fiscal dimensions. Validity was ensured through data triangulation (FGD transcripts, regulatory documents, international data), theoretical triangulation (three frameworks applied cross-sectionally), and

stakeholder triangulation (four categories with distinct institutional interests).

RESULT AND DISCUSSION

Result and Analysis

Indonesia's Power Sector: Emission Profile and ETS Architecture

Indonesia's power generation sector is heavily dominated by fossil fuels: of 101 GW installed capacity at end-2024, approximately 86 GW (85%) derives from fossil fuel-based plants (MEMR, 2025). Under ENDC targets, the energy sector must reduce emissions from 358 million tCO_2e under the unconditional pathway to 446 million tCO_2e under the conditional pathway by 2030, relative to a business-as-usual baseline. The national power system plan (RUKN 2025, MEMR Decree No. 85/2025) projects CO_2 emissions from power generation peaking at approximately 598 million tonnes in 2037 before declining toward net-zero by 2059 — a trajectory predicated on ETS and complementary instruments functioning as designed.

MEMR Regulation No. 16/2022 established a three-phase ETS roadmap: Phase 1 (2023–2024) covering CFPP with capacity ≥100 MW (expanding to ≥25 MW in 2024); Phase 2 (2025–2027) expanding to all CFPP; and Phase 3 (2028–2030) incorporating other fossil fuel-based generators. In Phase 1, 99 CFPP units participated in 2023, increasing to 146 units in 2024 — comprising 44 IPP-owned units in 2023 and 68 in 2024, alongside PLN Group-owned plants. PTBAE-PU is allocated based on emission intensity benchmarks (tCO_2e/MWh) adjusted for installed capacity class and plant location (pit-mouth vs. non-pit-mouth), with benchmarks tightened periodically in accordance with the regulatory schedule.

A critical structural feature distinguishes Indonesia's ETS from the EU's cap-and-trade design. Rather than setting a fixed total emission quantity, PTBAE-PU sets an intensity benchmark that, when multiplied by each plant's actual energy output, determines its individual allowance. This design means total system emissions are not capped in absolute terms — in principle, expansion in energy output could offset intensity benchmark improvements, creating a structural risk that aggregate emissions may not decline commensurately. Empirical verification of this effect requires longitudinal data beyond the two years of mandatory Phase 1 implementation available at the time of this study. This intensity-based approach closely parallels China's national ETS design; however, unlike China's 2024 reforms, Indonesia's system lacks an enforcement mechanism to penalise non-compliance.

Comparative analysis: EU ETS, China National ETS, and Indonesia ETS

Systematic comparison across three ETS systems reveals pronounced differences in design maturity, enforcement architecture, cap type, allocation methodology, price signals, and fiscal integration (Table 2). These differences directly inform the assessment of Indonesia's current system and the identification of reform pathways.

The EU ETS provides the most instructive long-term reference: two decades of progressive reform have shifted allocation from free to predominantly auctioned, established a functioning carbon price of €60–70/tCO_2e, and achieved verified emission reductions. The transition from Phase 1 (over-allocation, zero effective price signal) to Phase 4 (stringent cap, significant auctioning, market stability reserve) illustrates the institutional learning trajectory at the beginning of which Indonesia currently stands.

China's national ETS offers a more contextually comparable reference: both systems use intensity-based benchmarks with free allocation, both began with the power sector, and both operate within economies where fossil fuel dependence creates political constraints on rapid cap tightening. China's decisive advantage is its enforcement strengthening: the 2024 Interim Regulations introduced defined penalties for non-compliance, mandatory third-party verification through certified auditors, and sanctions for data fraud — establishing a credible compliance incentive that Indonesia's ETS entirely lacks. China's decade of regional pilot programmes (2013–2021) built the institutional learning, MRV capacity, and market infrastructure necessary before national scaling — a pathway that Indonesia's 2021 voluntary pilot

Table 2. Comparative architecture: EU ETS, China National ETS, and Indonesia power sector ETS

Dimension	EU ETS (Phase 4, 2021–2030)	China National ETS (2021–present)	Indonesia Power ETS (2023–present)
Operational since	2005 (Phase 1 pilot)	2021 (national, power sector)	2023 (mandatory Phase 1)
Coverage	Multi-sector: power, industry, aviation; ~11,000 installations; ~40% of EU emissions	Power sector only; >2,200 large installations; ~40–50% of national emissions (~4.5 Gt CO_2/yr)	CFPP ≥100 MW (2023); ≥25 MW (2024); on-grid plants only
Cap type	Absolute declining cap (−4.3%/yr from 2024)	Intensity-based benchmark (tCO_2/MWh)	Intensity-based benchmark (tCO_2/MWh)
Allocation method	Auctioning dominant (~57%); free allocation phasing out toward 2034	Free allocation (output-based, 100%); auctioning planned for future phases	Free allocation (100%); no auctioning planned in current roadmap
Enforcement mechanism	€100/tCO_2e excess penalty; must surrender missing permits; third-party verified MRV	2024 Interim Regulations: defined penalties and sanctions for non-compliance and data fraud	Carbon tax penalty regulation NOT YET ISSUED (as of April 2026); system effectively voluntary
Price signal (2024)	~€60–70/tCO_2e (functioning market)	~CNY 90/tCO_2 (~USD 12)	No functional market price; limited trading activity
MRV framework	Accredited third-party verifiers; EU-wide registry; annual verified reports mandatory	CETS platform; national registry; third-party verification required; 2024 regulations strengthened	APPLE-Gatrik (ESDM); third-party verifiers
Revenue use	Innovation Fund; Modernisation Fund; member-state climate budgets	National climate fund (planned for future phases)	No revenue generation mechanism
Fiscal integration risk	Low: polluter-pays firmly established; no state subsidy link	Low–moderate: implicit output subsidy in free allocation design	HIGH: GFM clause in PLN–IPP PPAs creates potential pathway to state energy subsidy budget or financial burden to PLN

Source: European Commission (2024); ICAP (2024); IMF (2024); MEMR (2025); Authors' analysis.

and 2023 mandatory Phase 1 have initiated but not yet completed.

ETS implementation by PLN group and IPPs

ETS implementation involves two distinct groups of participants. PLN Group (PT PLN Indonesia Power and PT PLN Nusantara Power) participates through an internal governance architecture including: BOD Regulation No. 161/2021 (Strategic Climate Change Management Policy); BOD Regulation No. 025/2022 (GHG Emission Management Standard Procedures); a signed MOU with the Directorate General of Electricity; and the PLN Climate Click digital platform (launched 2023) for Scope 1, 2, and 3 GHG inventory, permit trading between PLN Group plants, and integration with APPLE-Gatrik. By 2025, 82 PLN-owned CFPP units and 145 gas-fired generators are scheduled to participate in the ETS.

IPP participation is governed by separate contractual dynamics. By 2024, 68 IPP-owned CFPP units participated in Phase 1. IPPs have raised specific concerns through APLSI: (1) certainty of emission limits — benchmark intensities should be finalised without further tightening mid-cycle; (2) policy stability — regulatory changes requiring additional investment should not occur mid-contract; (3) PPA-aligned cap calculation — PTBAE-PU should reference contracted annual production targets rather than actual dispatch determined by PLN's Power Control Centre (P2B), since IPPs cannot control dispatch volume; and (4) fair emission accounting — total emission calculations should not penalise IPPs for outages or dispatch reductions ordered by PLN.

The fourth concern is particularly significant: because PLN's dispatch centre determines how much electricity each CFPP generates, IPPs do not independently control their total emission volume — only their emission intensity. This creates a fundamental attribution problem: if a plant is dispatched at high load, its total emissions increase even if its intensity (heat rate) remains within contracted specifications. The current PTBAE-PU design does not fully address this dispatch-attribution asymmetry.

The GFM–ETS fiscal compensation pathway

The most consequential finding of this study — and the primary theoretical contribution to ETS governance literature — is the identification and documentation of the GFM–ETS fiscal compensation pathway. This study documents the structural conditions under which the pathway could operate — contractual entitlement, regulatory cost trigger, and subsidy calculation linkage — rather than confirmed fiscal transfers already processed at measurable scale. FGD testimony from two regulatory informants confirms that the mechanism's structural logic and fiscal risk are institutionally recognised.

Stage 1 – Regulatory Cost Induction: Tightening of PTBAE-PU benchmark intensities increases ETS compliance costs for CFPP operators. Compliance options include: (a) purchasing additional PTBAE-PU permits on the carbon exchange; (b) purchasing emission reduction certificates (SPE) or carbon credits; or (c) investing in emission-reducing technologies. All three options involve costs not reflected in existing PPAs.

Stage 2 – GFM Clause Activation: ETS regulation (MEMR Regulation No. 16/2022) constitutes a "Change in Law" under GFM clauses in the standard PLN–IPP PPA — it is a new government regulation imposing obligations that did not exist at the time of PPA signing and directly affecting the seller's ability to meet contracted obligations. IPPs are contractually entitled to notify PLN of cost increases attributable to the GFM trigger.

Stage 3A – Allowable Cost Classification: If ETS compliance costs are classified as allowable costs in the COGS calculation under MoF Regulation 174/2019 (as amended by MoF Regulation 178/2021), PLN's approved costs increase, triggering higher subsidy claims from PLN to the government. The Fiscal Policy Agency informant confirmed: "If it is classified as allowable cost, it will of course become part that must be paid by the government as it enters into the electricity subsidy calculation" (Wahyu Utomo, FGD 2025). The Director General of Electricity confirmed: "At present, the impact from the power plants is charged to the government, which ultimately adds to the subsidy" (Jisman P. Hutajulu, FGD 2025).

Stage 3B – Non-Allowable Cost Classification: If classified as non-allowable — as determined in MoF Regulation No. 20/2025 — PLN must absorb the cost increase from its own financial resources, since PLN cannot pass costs to consumers through tariff adjustments (tariffs are set by the government). This erodes PLN's financial position and creates pressure for PPA renegotiation with IPPs — a process with significant legal and commercial risks given the approximately 30-year PPA durations and international arbitration provisions.

This pathway, if activated through formal GFM claims and confirmed allowable cost classification, would structurally invert the polluter-pays principle: rather than CFPP operators bearing the social cost of their GHG emissions, the fiscal burden could transfer first to PLN and then — through the subsidy mechanism — to Indonesian taxpayers. As PTBAE-PU benchmarks would need to be progressively tightened in pursuit of NDC targets, the potential state subsidy exposure would correspondingly increase, creating a structural constraint on ETS ambition. The GFM–ETS pathway has not been previously identified in ETS governance literature, representing a novel governance failure mode specific to economies where fossil fuel electricity generation is supplied through long-term state-contracted PPAs with cost-recovery clauses. The structural mechanism is illustrated schematically in Annex 1.

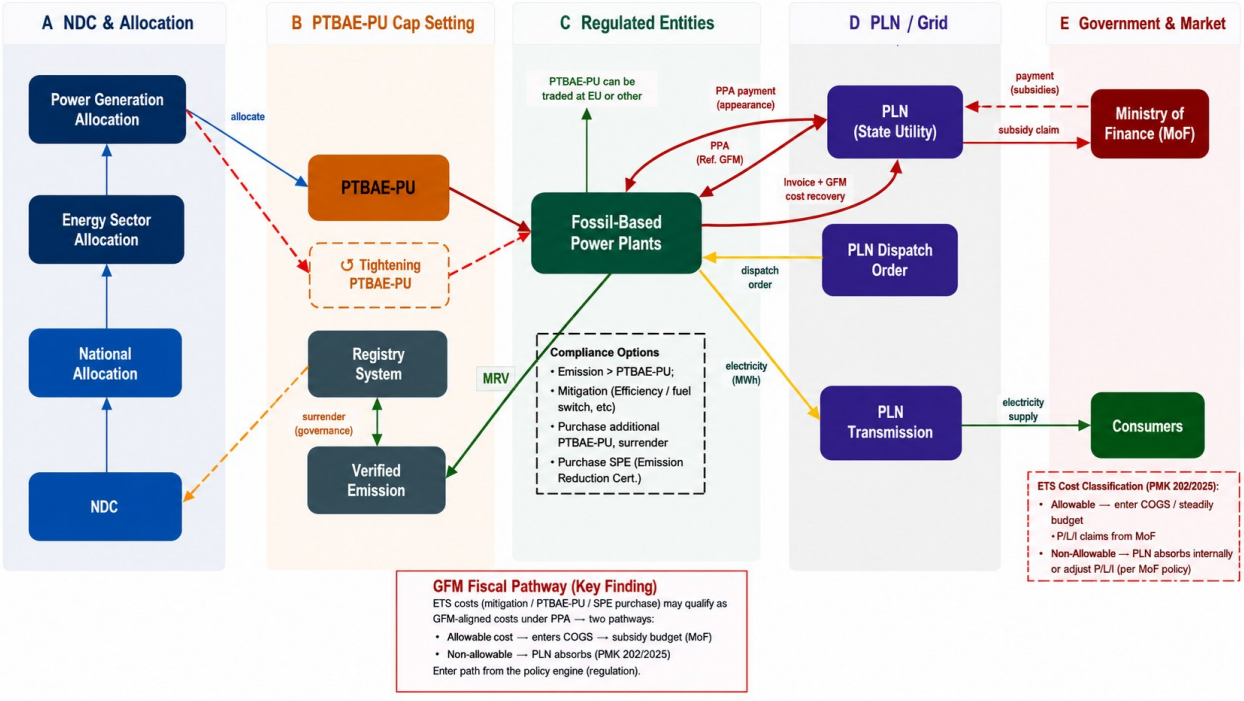
NVivo coding analysis: dominant governance nodes

Hierarchical node analysis of six FGD transcripts identified 13 principal coding nodes across two thematic systems: "Emission Trade Governance" (addressing RQ1) and "Capping Mechanism" (addressing RQ2). Three nodes emerged with the highest reference counts and broadest cross-stakeholder citation coverage. Coverage percentages reflect the proportion of informant categories citing the node within the six-informant sample: 84% represents five of six informants; 72% represents four of six. These figures indicate cross-expert convergence rather than statistically generalisable prevalences.

Table 3. Top governance nodes from NVivo hierarchical coding analysis

Governance Node	References (n)	Coverage	Key Stakeholder Evidence and Policy Significance
Technology & Digitalization	5	84% (5/6)	APPLE-Gatrik for ESDM MRV since 2018; PLN Climate Click (launched 2023) for GHG inventory and permit trading; need for unified national carbon registry; digital infrastructure as prerequisite for credible MRV and market price formation
National Regulation Completeness	5	84% (5/6)	Absence of MoF carbon tax penalty regulation (Law 7/2021) renders ETS voluntary; fragmented multi-ministry MRV reporting creates data inconsistencies; regulatory certainty identified by informants as primary barrier to long-term low-carbon investment decisions
Cost of Goods Sold (COGS/BPP)	5	84% (5/6)	ETS compliance costs impact CFPP COGS; GFM clause creates allowable vs. non-allowable cost classification uncertainty; potential government subsidy budget exposure; IPP contractual rights to cost recovery
Capping Mechanism (Bottom-Up)	4	72% (4/6)	Strong stakeholder preference for plant-level data aggregation as basis for PTBAE-PU; heat rate-based alternative proposed by APLSI to eliminate GFM transfer; concern that top-down caps create unmanageable compliance burdens for diverse coal fleet
Enforcement / Compliance Incentive	4	72% (4/6)	Absence of carbon tax enforcement creates rational non-compliance; penalty rate (IDR 30/kgCO_2e per Law 7/2021) considered insufficient relative to abatement costs; cross-stakeholder recognition that voluntary ETS cannot achieve NDC targets
CBAM Competitiveness	3	65% (4/6)	EU Carbon Border Adjustment Mechanism (effective 2026) creates external pressure for ETS compliance; Indonesian industrial exporters face competitive disadvantage if domestic ETS is not credible; CBAM as positive externality driver for ETS reform

Source: NVivo analysis of FGD transcripts (Authors, 2025). References = number of coding instances; Coverage = proportion of informant categories citing node (n=6).



Annex 1: GFM Fiscal Pathway

Technology and Digitalization emerged as the most consistently emphasised governance node. The PLN operator informant documented PLN Climate Click's functionality for Scope 1, 2, and 3 inventory tracking, inter-unit permit trading within PLN Group, and planned integration with APPLE-Gatrik. The MEMR regulator highlighted significant gaps in real-time monitoring, cross-platform interoperability, and integration with a unified national carbon registry. The IPP association informant noted that digitalisation is necessary but insufficient without regulatory certainty — data systems alone cannot substitute for an enforceable compliance framework. National Regulation Completeness centred on the non-issuance of the MoF carbon tax penalty regulation mandated by Law No. 7/2021, Chapter VI, Article 13. The academic informant stated: "Carbon tax that has not been implemented — if this can be applied, even if later applied to fossil power plants, it will certainly provide a disincentive for the use of fossil energy" (Surya Darma, FGD 2025; translated from Indonesian). Additional regulatory gaps included the absence of a unified multi-sector emission reporting platform and the pending implementation of regulations under Presidential Regulation No. 110/2025.

Cost of goods sold (COGS) reflected shared concern across all stakeholder categories about the cost implications of ETS compliance. The APLSI informant articulated the mechanism: "Emission trading, of course, creates costs, especially from the COGS side — there is certainly an impact on operational costs" (Arthur Simatupang, FGD 2025; translated from Indonesian). The MEMR regulator confirmed: "Currently it is not specifically regulated, and this is a challenge for us in the field — at present the impact from the power plants is charged to the government, which ultimately adds to the subsidy" (Jisman P. Hutajulu, FGD 2025; translated from Indonesian). The Ministry of Finance informant noted that current regulatory interpretation treats ETS compliance costs as non-allowable in BPP calculation, reflecting the government's preference for the polluter-pays principle — but acknowledged that without formal PMK revision, this classification remains legally uncertain and contestable by IPPs through PPA arbitration.

Cap-setting approaches: bottom-up vs. top-down analysis

FGD analysis and comparative institutional review reveal two fundamental cap-setting approaches with significantly different implications for environmental effectiveness, fiscal sustainability, and political feasibility.

Top-Down Approach: PTBAE-PU is derived from Indonesia's national NDC emission reduction target (1,311 million tCO_2 for the energy sector cumulatively through 2030), disaggregated to the power sub-sector and allocated to individual plants. This approach provides environmental predictability but requires a mature institutional infrastructure currently absent in Indonesia. In the present context — with incomplete MRV integration, absent enforcement, and significant heterogeneity in the CFPP fleet — a purely top-down approach risks either over-burdening older plants whose compliance costs are then transferred to the state through the GFM mechanism or setting benchmarks so lenient as to have no environmental effect.

Bottom-Up Approach: The cap is derived by aggregating plant-level emission intensity data collected through mandatory MRV reporting, then progressively tightened against a nationally consistent declining trajectory aligned with NDC sub-sectoral targets. This approach — consistent with China's national ETS design logic and endorsed as a preference by informants across all four stakeholder categories — permits gradual tightening calibrated to actual plant characteristics: fuel calorific values in existing PPAs, contracted heat rate, plant technology class, and historical emission intensity data from APPLE-Gatrik. It avoids the fiscal shock of excessively rapid benchmark tightening while maintaining progressive alignment with NDC sub-sectoral trajectories.

Heat Rate-Based PTBAE-PU: A technically innovative alternative raised by the APLSI informant proposes basing PTBAE-PU on each plant's contractual heat rate as specified in its PPA. Since heat rates represent the contractual energy efficiency commitment already accepted by both parties, this approach would: (a) eliminate the GFM cost-transfer mechanism — if a plant's actual emission intensity exceeds what its contractual heat rate implies, responsibility rests unambiguously with the operator; (b) align compliance

obligations with contractual capabilities; and (c) create a direct incentive for operators to maintain heat rate performance. This approach warrants further technical development and stakeholder consultation.

Recommended Hybrid Approach: A hybrid bottom-up/top-down methodology is proposed: bottom-up plant-level data collection via mandatory, unified MRV for emission intensity, heat rate, calorific values, and technology specifications; aggregation to a sub-sector total with a nationally consistent declining trajectory corridor aligned with NDC targets; mandatory benchmark tightening schedules reviewed triennially; and progressive reduction in free allocation toward partial auctioning as the carbon market matures and institutional capacity develops.

Discussion

Theoretical contributions

This study makes three principal contributions to ETS governance theory and the broader literature on carbon pricing in emerging economies. First, the GFM–ETS fiscal compensation pathway constitutes a novel governance failure mode. While ETS literature has extensively analysed free allocation windfall profits (Grubb & Neuhoff, 2006), market fragmentation (Liu et al., 2015), and enforcement gaps (Wang et al., 2019), the specific mechanism whereby long-term contractual GFM provisions may systematically transfer emission compliance costs from polluters to the state — potentially inverting the polluter-pays principle — has not been previously theorised. This finding extends government externality theory (Trantidis, 2023) by demonstrating that institutional design failures at the interface of regulatory and contractual frameworks can generate potentially self-defeating policy architectures. The structural logic — where tightening the cap simultaneously increases the state's potential fiscal exposure through the GFM–COGS–subsidy pathway — has implications for any developing economy where fossil fuel electricity generation is supplied through long-term state-contracted PPAs with cost-recovery provisions.

Second, the study advances understanding of ETS de facto voluntariness. While enforcement failures in developing-country ETS have been documented (Wang et al., 2019; Deng et al., 2018), this study demonstrates that the absence of a single downstream instrument — the MoF carbon tax penalty regulation — can render an entire ETS framework operationally voluntary regardless of the sophistication of its upstream regulatory architecture. The institutional lesson extends beyond Indonesia: any ETS that separates the compliance obligation framework from its enforcement instrument across separate regulatory instruments issued by separate ministries carries this systemic risk. Enforcement instruments must be developed concurrently with, not after, the primary ETS regulation.

Third, applying Energy Transition Theory (IEA, 2024) to Indonesia's ETS reveals a systemic governance pattern. The three dominant governance nodes identified by FGD informants — Technology and Digitalization, National Regulation Completeness, and COGS — correspond to three of the enabling conditions for successful energy transition: technological infrastructure, regulatory stability, and investment economics, respectively. Their simultaneous and equally weighted salience across all four stakeholder categories suggests that Indonesia's ETS faces a systemic governance deficit rather than isolated regulatory gaps. Addressing any single node in isolation is unlikely to generate the behavioural change necessary for NDC achievement; reform must be designed as an integrated institutional package targeting all three dimensions concurrently. Hickel and Kallis (2020) reinforce this point: structural decoupling requires institutional completeness, not piecemeal reform.

The subsidy and tariff architecture as a structural impediment to ETS effectiveness

The prevailing policy architecture governing electricity subsidies, compensation payments, and tariff-setting constitutes one of the structural root causes impeding the implementation of the energy transition and the effective functioning of the ETS in the power generation sub-sector. From a regulatory standpoint, this mechanism is governed by several interlocking layers of legislation:

(i) Law No. 30 of 2009 on Electricity, as amended by Law No. 6 of 2023 on Job Creation, which stipulates that electricity tariffs are determined by the Government subject to parliamentary approval by the House of Representatives (DPR); (ii) Government Regulation No. 14 of 2012 on Electricity Supply Business Activities and its amendments; and (iii) Minister of Finance Regulation No. 174/PMK.02/2019, as amended by PMK No. 178/PMK.02/2021, on the Procedures for the Provision, Calculation, Payment, and Accountability of Electricity Subsidies, which defines the electricity subsidy as state expenditure allocated to cover the shortfall between the Average Electricity Tariff (TTL — Tarif Tenaga Listrik) and the Cost of Service Provision (BPP — Biaya Pokok Penyediaan) plus an approved margin. In addition to the subsidy instrument, the Government also disburses compensation to PT PLN (Persero) to cover revenue shortfalls arising from a price-setting policy that places the mandated tariff below the economic cost of supply, as reflected in the combined realisation of electricity subsidies amounting to approximately IDR 77.04 trillion in fiscal year 2024.

This policy structure gives rise to three critical implications for the ETS. First, government-determined electricity tariffs — which require parliamentary approval prior to any revision — deprive PLN of the operational flexibility to pass through increases in operational costs, including ETS compliance costs, to end consumers. This institutional constraint is directly relevant to the GFM–ETS fiscal compensation pathway identified in Section 4.4: because PLN cannot adjust the retail tariff in response to cost increases passed through under GFM clauses, those costs are channelled upward to the state subsidy budget rather than transmitted to the point of consumption.

Second, the BPP formula, defined as the sum of fuel costs and fixed costs, does not explicitly accommodate ETS compliance expenditure, creating regulatory uncertainty as to whether PTBAE-PU compliance costs constitute an allowable cost eligible for inclusion in the BPP calculation — and therefore recoverable through the subsidy mechanism — or a non-allowable cost that must be absorbed by the relevant entity without recourse to public funds. This classification ambiguity is the operative mechanism through which the GFM–ETS fiscal pathway functions: if PTBAE-PU compliance expenditure is classified as allowable, its inclusion in BPP directly increases the subsidy entitlement, transferring the carbon cost from the emitter to the state.

Third, fiscal dependence on the domestic coal price subsidy — administered through a reference price ceiling of USD 70 per tonne pursuant to Minister of Energy and Mineral Resources Decision No. 139.K/2021 — has introduced a price distortion that attenuates the carbon price signal generated by the ETS. By suppressing the input cost of the principal emitting fuel below its international market price, this instrument partially offsets the financial incentive to decarbonise that the PTBAE-PU compliance obligation is designed to create. Overall, the government's tariff-setting architecture affords PLN no latitude to adjust retail electricity prices in response to operational cost changes, thereby impeding the effective internalisation of carbon externality costs as required by the polluter-pays principle — the normative benchmark identified in the theoretical framework.

Operational implications for CFPP participants

The FGD findings and comparative institutional analysis identify two operational implications for CFPP participants that the current regulatory framework does not adequately address. First, the dispatch-attribution asymmetry identified in Section 4.3 has direct implications for compliance equity. Because PLN's centralised dispatch centre determines each CFPP's operating load, individual plant operators cannot independently control their total emission volume — only their intensity per MWh. Under the current PTBAE-PU design, a plant dispatched at high load to meet grid demand may breach its annual emission cap despite operating within its contracted heat rate specification. This attribution problem creates compliance risks partially exogenous to plant-level technical performance, undermining the polluter-pays logic of intensity-based benchmarking. The APLSI informant's testimony directly identifies

this gap and supports a benchmark adjustment mechanism that accounts for PLN-directed dispatch variability.

Second, the technology heterogeneity of Indonesia's CFPP fleet — with subcritical plants constituting the majority of Phase 1 participants — implies that uniform benchmark tightening creates differentiated compliance burdens across technology classes. Plants with older technology face physical efficiency constraints that limit the degree to which heat rate optimisation alone can close the compliance gap (World Bank, 2019). This differentiation is not addressed by the current uniform benchmark design and has implications for the pace at which benchmark tightening can be implemented without creating GFM-triggering cost shocks for older IPP-contracted units.

Key lessons from the comparative analysis

Two institutional lessons from the comparative analysis are of direct analytical relevance to Indonesia's reform trajectory. The China comparison yields the most applicable lesson: the transition from operationally weak pilot-phase compliance (2013–2021) to the 2024 Interim Regulations — which introduced defined non-compliance penalties, mandatory third-party verification, and sanctions for data fraud — illustrates that enforcement strengthening is achievable incrementally within an intensity-based framework. Indonesia is at a structurally equivalent early stage. The China trajectory demonstrates that the enforcement gap is not a permanent feature of developing-economy ETS but a design sequencing problem addressable through deliberate institutional commitment. It also demonstrates that this transition required over a decade of accumulated experience — a timeline that Indonesia's NDC 2030 commitments may not permit, absent accelerated reform.

The EU comparison provides a longer-term institutional reference: Phase 1 over-allocation and zero effective price signal gave way progressively to Phase 4 stringency, significant auctioning, and a functioning carbon price of €60–70/tCO_2e. The analytical lesson is that ETS effectiveness is achieved through sustained, incremental reform calibrated to accumulated data and institutional capacity — not through regulatory ambition unsupported by enforcement infrastructure. Indonesia is at the Phase 1 equivalent of its ETS trajectory. Addressing the enforcement gap before seeking to generate genuine price signals through permit scarcity is the institutional prerequisite for every subsequent reform.

CONCLUSION

Conclusion and policy recommendation

This study draws several principal conclusions from the comparative institutional analysis, secondary data analysis, and FGD qualitative research. Two additional observations — concerning coal supply and CFPP operational dynamics — are presented separately as theoretically derived potential implications rather than direct empirical findings, as they extend beyond the primary evidence base of this study and require quantitative modelling for validation.

The principal conclusions include; ETS is operationally voluntary. The non-issuance of the MoF penalty regulation under Law No. 7/2021 means that PTBAE-PU non-compliance carries no material financial consequence. Without enforcement, the ETS cannot generate a credible carbon price signal, cannot incentivise low-carbon investment decisions, and cannot achieve NDC sub-sectoral targets. This is the most urgent structural deficiency that warrants immediate regulatory remediation.

Three governance nodes represent the minimum institutional prerequisites for a functional ETS. Technology and Digitalization, National Regulation Completeness, and COGS were each cited by five of six FGD informants across all stakeholder categories, reflecting cross-expert convergence on the system's foundational gaps. Their simultaneous incompleteness creates a systemic governance deficit: without reliable MRV data, without enforceable regulation, and without a resolved fiscal interface between ETS compliance costs and subsidy accounting, no element of the ETS can function as designed.

The GFM–ETS fiscal compensation pathway constitutes a structurally identified risk of polluter-pays principal inversion. The interaction between PTBAE-PU compliance obligations and GFM

clauses in PLN–IPP PPAs creates the contractual and regulatory conditions under which ETS compliance costs could be transferred from emitters to the state subsidy budget. This study documents the structural mechanism and the regulatory provisions through which it operates, validated by FGD expert testimony from two regulatory informants confirming its institutional logic. This represents a structural risk identified through institutional analysis during the early stage of ETS implementation — not a confirmed fiscal transfer already observed at scale. As a novel governance failure mode not previously identified in ETS literature, it has direct implications for developing-economy carbon market design wherever state-contracted power generation is prevalent.

Indonesia's ETS shares structural features with China's national carbon market but critically lacks China's enforcement architecture. Both systems use intensity-based benchmarks, free allocation, and concentration of coverage in the power sector. China's decisive institutional advantage is its progressive enforcement strengthening through the 2024 Interim Regulations. Indonesia has not made this transition, and the gap is not one of degree but of fundamental system architecture.

A bottom-up, data-driven approach to PTBAE-PU cap-setting is most appropriate for Indonesia's current institutional context. Gradual benchmark tightening calibrated to actual plant characteristics — heat rate, technology class, fuel specifications — maintains progressive alignment with NDC sub-sectoral targets while avoiding the fiscal shock of excessively rapid tightening that could activate GFM claims at scale. A heat rate-based PTBAE-PU, grounded in pre-existing PPA contractual commitments, offers the structural benefit of eliminating the GFM cost-transfer mechanism.

Theoretically Derived Potential Implications. Beyond the five conclusions directly supported by the primary evidence, two implications are noted as warranting further empirical investigation. First, as PTBAE-PU benchmarks tighten progressively under MEMR Regulation No. 16/2022, carbon pricing theory predicts structural demand contraction for domestic coal supply through heat rate improvement and partial fuel displacement, with associated stranded asset risks for coal-dependent communities and industries (Fischer & Springborn 2011; Caldecott et al., 2017). Second, the dispatch-attribution asymmetry arising from PLN's centralised dispatch authority creates compliance risks for CFPP operators that are partially exogenous to plant-level technical performance, suggesting that the current uniform benchmark design may require adjustment for technology class and dispatch variability. Both implications are identified as priority areas for future quantitative research.

Policy recommendations

Recommendation 1 – Issue Enforcement Regulation (Urgent Priority). The Ministry of Finance must immediately issue the implementing regulation on carbon tax mechanisms under Law No. 7/2021, establishing a penalty structure for PTBAE-PU non-compliance. The regulation should specify the penalty rate per tCO_2e of excess emissions, the payment collection and compliance verification procedure, and the escalation path for persistent non-compliance. Without this regulation, all other ETS governance improvements remain structurally undermined by the absence of a compliance incentive.

Recommendation 2 – Resolve the GFM–ETS Fiscal Interface. MoF Regulation No. 20/2025 classifying ETS compliance costs as non-allowable in COGS calculation upholds the polluter-pays principle and should be codified as a permanent regulatory position. Concurrently, MEMR and PLN should develop a framework for future PPA negotiations that explicitly excludes post-PPA ETS obligations from GFM coverage, accompanied by a transition financing mechanism to assist IPPs in funding compliance investments without triggering GFM claims.

Recommendation 3 – Establish an Integrated National MRV Digital Platform. A unified, cross-ministerial emission reporting platform integrating APPLE-Gatrik (MEMR) with the Ministry of Environment and Ministry of Industry reporting systems should be developed, enabling single-submission reporting by regulated entities. The platform should incorporate standardised emission calculation methodologies, automated third-party

verification workflows, a national carbon permit registry linked to trading infrastructure, and public transparency dashboards.

Recommendation 4 – Adopt Hybrid Bottom-Up Cap-Setting with Heat Rate Integration. PTBAE-PU methodology should be revised to: (a) base initial benchmarks on aggregated plant-level MRV data; (b) incorporate contractual heat rate and fuel calorific specifications from existing PPAs to address the dispatch-attribution asymmetry; (c) establish mandatory tightening schedules reviewed triennially against actual emission trajectories; and (d) pilot a heat rate-based PTBAE-PU for IPPs in Phase 2 as a proof -of-concept for the GFM-neutral approach.

Recommendation 5 – Establish a Dedicated Carbon Market Authority. As ETS expands under Presidential Regulation No. 110/2025, governance should be consolidated under a dedicated cross-sectoral carbon market authority responsible for MRV standard-setting, permit registry management, and market surveillance, progressive introduction of auctioning with revenue allocation to green investment funds, sector coverage expansion, and coordination with international carbon market standards.

Recommendation 6 – Develop Technology-Differentiated Benchmarks. The uniform PTBAE-PU benchmark design should be revised to incorporate technology-class differentiation — separate intensity standards for subcritical, supercritical, and ultra-supercritical plant categories — consistent with their respective efficiency constraints (World Bank, 2019). A benchmark adjustment mechanism should be developed that accounts for PLN-directed dispatch variability in annual compliance assessments, ensuring that operators are not penalised for emission volumes attributable to centralised dispatch decisions rather than plant-level operational performance.

Recommendation 7 — Reform Subsidy Delivery and Electricity Tariff-Setting to Enable Effective Carbon Cost Transmission. The Government should reform the modality of electricity subsidy and compensation delivery. The electricity subsidy, hitherto channelled through PLN as an intermediary, should be converted into a direct transfer to eligible beneficiaries (*targeted subsidy*). Under a direct subsidy mechanism, PLN would no longer serve as the conduit for subsidy disbursement and would therefore be empowered to set electricity tariffs on the basis of a transparent Cost of Service Provision (BPP) calculation that genuinely reflects the economic cost of supply, including the ETS compliance cost component. This reform is consistent with the policy direction articulated in the National Medium-Term Development Plan (RPJMN) 2025–2029, which calls for improved targeting accuracy in energy subsidies, and directly addresses the first critical implication identified in the Discussion section above. In addition, the Government should revise the electricity tariff-setting procedure. Under the current provisions of Law No. 30 of 2009, as amended by Law No. 6 of 2023, electricity tariffs are determined by the Government with parliamentary approval — a mechanism that structurally eliminates PLN's flexibility to adjust tariffs responsively to changes in operational costs. Should the subsidy delivery modality be successfully transitioned to direct household transfers, the Government should examine the feasibility of introducing an *automatic tariff adjustment mechanism* that would authorise PLN to revise tariffs periodically in accordance with a government-established formula indexed to changes in BPP, the prevailing exchange rate, and fuel prices. Under such an arrangement, PLN would be able to set electricity tariffs on the basis of a transparent cost of goods sold (COGS) calculation, enabling the carbon price signal to be transmitted effectively throughout the electricity value chain. This reform is essential to the long-term functioning of the ETS: without a tariff mechanism that allows PLN to reflect ETS compliance costs in retail prices, the carbon externality cannot be internalised at the point of consumption, regardless of how stringent the PTBAE-PU regime becomes.

In the context of ETS implementation, the Government must also explicitly classify PTBAE-PU compliance expenditure as a *non-allowable cost* for the purposes of electricity subsidy and compensation calculation under PMK No. 174/2019, as amended by PMK No. 178/2021 — a position already taken in MoF Regulation No. 20/2025 and consistent with Recommendation 2 above. This classification must be accompanied by

a requirement to renegotiate Power Purchase Agreements (PJBLs) to incorporate explicit emissions trading clauses, as recommended in Recommendation 4. Together, these measures constitute the necessary preconditions to prevent the GFM mechanism embedded in PJBLs from functioning as a channel through which carbon compliance costs are transferred to the national budget (APBN), and to ensure that the polluter-pays principle is consistently upheld within the ETS governing the power generation sub-sector.

Limitations and future research directions

This study is subject to limitations that define opportunities for future research. Primary data derive from six expert informants in a single FGD event; future research should employ larger-scale stakeholder surveys across multiple rounds, longitudinal case studies tracking policy implementation, and econometric analysis of emission outcomes relative to PTBAE-PU benchmark trajectories. The fiscal impact of alternative PTBAE-PU scenarios on state subsidy expenditure is characterised qualitatively; quantitative modelling of subsidy implications under varying benchmark tightening trajectories would significantly strengthen the policy case. Future research should also address: (1) quantification of the GFM fiscal exposure under different compliance cost scenarios; (2) distributional impacts of ETS expansion on electricity tariff affordability; (3) the optimal carbon tax penalty rate relative to abatement costs; (4) readiness of Indonesia's industrial exporters for EU CBAM compliance obligations effective 2026; and (5) conditions under which Indonesia's ETS could credibly link with international ETS — a pathway requiring first establishing domestic enforcement credibility.

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DECLARATIONS

Author contribution

Paul PM Butarbutar: conceptualization, methodology, investigation, data curation, formal analysis, software, visualization, writing original draft, writing review & editing. Prof. E. Sofilda: Supervision, visualization, methodology, validation, writing review. Prof. M. Zilal: Supervision, methodology, validation, writing review.

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The author(s) used Claude to assist in the refinement of the draft. After using this tool, the authors review and edit the content as needed, taking full responsibility for the publication's content.

GLOSSARY OF TERMS AND SYMBOLS

Terms & Symbols	Definition	Unit
APLSI	Asosiasi Produsen Listrik Swasta Indonesia — the Indonesian Independent Power Producers Association.	

APPLE-Gatrik Aplikasi Perhitungan Pelaporan Emisi (Gatrik) — MEMR's emissions calculation and reporting platform for the electricity sub-sector.

BPP Biaya Pokok Penyediaan — the basic cost of electricity supply; the Indonesian term corresponding to Cost of Goods Sold (COGS) in the subsidy formula.

CBAM Carbon Border Adjustment Mechanism — the European Union's border carbon levy on imported goods, with reporting obligations effective 2026.

CETS China Emission Trading System — China's national carbon emissions trading platform and registry.

CFPP Coal-Fired Power Plant — fossil-fuel generating facilities that are the principal source of power-sector GHG emissions in Indonesia.

COGS Cost of Goods Sold — the production cost basis (Biaya Pokok Penyediaan, BPP) used in the electricity subsidy formula.

ENDC Enhanced (Nationally Determined Contribution) — Indonesia's strengthened emission-reduction commitment under the Paris Agreement.

ESDM Energi dan Sumber Daya Mineral — the Ministry of Energy and Mineral Resources (MEMR).

ETS Emission Trading System — a market-based carbon-pricing mechanism capping emissions and allowing trade of allowances.

FGD Focus Group Discussion — the expert-informant primary-data method used in this study.

GFM Government Force Majeure — a cost-recovery clause in Power Purchase Agreements triggered when new government regulation increases an operator's costs after contract execution.

GHG Greenhouse Gas — emissions (principally CO_2) targeted by the ETS and NDC.

ICAP International Carbon Action Partnership — an international forum on emissions trading systems and a source of comparative ETS data.

IPP Independent Power Producer — a private electricity generator supplying PT PLN under a long-term Power Purchase Agreement.

IRID Indonesia Research Institute for Decarbonization — a civil-society research organisation represented among the FGD informants.

KLHK Kementerian Lingkungan Hidup dan Kehutanan — the Ministry of Environment and Forestry.

MEMR Ministry of Energy and Mineral Resources (Kementerian ESDM) — the regulator establishing the power-sector ETS.

MoF Ministry of Finance — the body responsible for issuing the outstanding penalty (carbon-tax) regulation mandated by Law No. 7/2021.

MRV Measurement, Reporting and Verification — the system ensuring the

	the integrity of reported emissions data under an ETS.
NDC	Nationally Determined Contribution — a country's emission-reduction commitment under the Paris Agreement.
NEK	Nilai Ekonomi Karbon (Carbon Economic Value) — the carbon-pricing framework established by Presidential Regulation No. 98/2021.
P2B	Pusat Pengatur Beban (Power Control Centre) — PT PLN's dispatch-control unit determining generation volumes.
PLN	PT Perusahaan Listrik Negara (Persero) — the Indonesian state-owned electricity utility.
PMK	Peraturan Menteri Keuangan — Minister of Finance Regulation, the instrument required to revise the subsidy-cost classification.
PPA	Power Purchase Agreement — the long-term contract between PT PLN and an Independent Power Producer.
PTBAE-PU	Persetujuan Teknis Batas Atas Emisi Pelaku Usaha — the Technical Approval of the Upper Emission Limit for Business Actors; the plant-level emission allowance and cap.
RUKN	Rencana Umum Ketenagalistrikan Nasional — the National Electricity General Plan.
SPE	Sertifikat Pengurangan Emisi — Emission Reduction Certificate, a tradable compliance instrument under the NEK framework.

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