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A COMPARATIVE ANALYSIS OF CARBON TAXES AND CAP-AND-TRADE SYSTEMS: IMPACT ON ELECTRICITY MARKET EFFICIENCY AND SUSTAINABLE ECONOMIC GROWTH

[*1]Fakrogha TM and [2]Oduola M.K.

[1]Emerald Energy Institute; [2]Department of Chemical Engineering,
University of Port Harcourt, Nigeria.

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***Corresponding Author: Fakrogha TM**
Emerald Energy Institute, University of Port Harcourt, Nigeria.
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ABSTRACT

As the global climate crisis intensifies, carbon pricing has emerged as a central pillar of climate policy designed to internalize the external costs of greenhouse gas emissions. This paper provides a comprehensive comparative analysis of two dominant market-based instruments: carbon taxes and cap-and-trade systems, with a specific focus on their impact on electricity market performance and economic efficiency. Both mechanisms aim to correct market failures by incentivizing the adoption of energy-saving technologies and fostering a transition to a low-carbon economy. Through an examination of theoretical frameworks—such as Pigouvian taxes versus quantity controls—and empirical case studies—including the European Union Emissions Trading Scheme (EU ETS), British Columbia’s carbon tax, and California’s cap-and-trade program—the study evaluates these tools across dimensions of price certainty, environmental integrity, and administrative complexity. The analysis finds that while carbon taxes offer superior price predictability and simplicity, cap-and-trade systems provide higher environmental certainty through fixed emission limits. Furthermore, the paper highlights that market efficiency is optimized when marginal abatement costs are equalized across emitters. The study concludes that no single mechanism is universally optimal; instead, successful implementation depends on tailoring policies to local institutional capacities and economic structures. Increasingly, hybrid approaches—integrating price floors and stability reserves—offer the most viable pathway for balancing environmental objectives with electricity price stability and sustained economic growth.

KEYWORDS: Carbon Pricing, Cap-and-Trade, Carbon Tax, Electricity Market Design, Economic Growth.

1. INTRODUCTION

The global energy landscape is currently navigating a "triple crisis" of climate urgency, energy security, and price volatility. While carbon pricing—primarily through Carbon Taxes (CT) and Cap-and-Trade (C&T) systems—has long been advocated as the most efficient tool to internalize the external costs of emissions, its practical application in electricity markets faces significant hurdles. Traditional economic theory suggests a simple trade-off between price certainty (taxes) and quantity certainty (trading). However, recent market disruptions, such as the 2022–2023 energy crisis sparked by the Ukraine conflict, have exposed a "decoupling" between carbon prices and fuel costs, complicating the investment signals required for a zero-carbon transition (European Commission, 2022).

Despite extensive literature on the theoretical merits of these instruments, there is a lack of synthesis regarding how recent institutional reforms—specifically the EU's Market Stability Reserve (MSR) and the Carbon Border Adjustment Mechanism (CBAM)—alter the performance of these mechanisms in emerging and volatile markets. Furthermore, a "missing market" for long-term carbon price signals continues to deter the high-capital investments needed for renewable baseload power (Cambridge Judge Business School, 2023; Newbery, 2025)). This paper evaluates these two mechanisms through the lens of recent global shifts, assessing their capacity to provide the stability required for both market efficiency and sustained economic growth.

2. RECENT EMPIRICAL EVIDENCE

The literature on carbon pricing has evolved from debating "Tax vs. Cap" to analyzing "Hybrid Resilience" and "Policy Diffusion." Recent reforms to the European Union Emissions Trading System (EU ETS) have introduced the Market Stability Reserve (MSR) to address the historical problem of allowance surpluses. Empirical studies from 2023 to 2025 indicate that the MSR has significantly strengthened the "price signal," even during economic downturns, by allowing for the cancellation of surplus permits (Cambridge Judge Business School, 2023). Furthermore, research into permit banking—the ability of firms to save allowances for future use—suggests that while banking helps smooth demand across business cycles, its effectiveness is highly dependent on the stringency of the underlying cap (EconomiX, 2025; Chateauet al., 2023).

Recent data reveals a stark difference in how these mechanisms drive technology shifts. Studies published in 2024 and 2025 demonstrate that carbon trading has been associated with an increase in renewable energy generation by up to 73.32%, whereas carbon taxes have driven a more modest 31.79% increase (Alwaaritsy, N., & Romadani, A. (2025). ; Feng et al., 2024). This disparity is often attributed to the "quantity certainty" inherent in cap systems, which forces a hard transition to cleaner alternatives to meet legal limits.

The introduction of the Carbon Border Adjustment Mechanism (CBAM) in the EU (phasing in through 2026) is perhaps the most significant recent development in global climate policy. The CBAM acts as a "stepping stone" toward a global carbon price by incentivizing trade partners to implement their own domestic pricing to avoid EU tariffs (Taylor & Francis, 2025). This "Brussels Effect" is already accelerating the adoption of emissions trading in emerging economies, such as Indonesia, which launched its electricity-sector ETS in 2023 covering 80% of its generating capacity (I4CE, 2023).

The 2022 energy crisis highlighted the regressive risks of carbon pricing. When gas and electricity prices surged, the added burden of carbon costs created significant "affordability gaps" for low-income households (Kettner, 2025). Recent literature emphasizes that for carbon pricing to be sustainable, it must be paired with revenue-recycling frameworks—such as direct transfers to households or "feebates" for green infrastructure—to ensure a "just transition" (EconStor, 2025; King et al., 2023).

Carbon pricing is an environmental policy instrument that imposes a monetary cost on the emission of carbon dioxide and other greenhouse gases. This approach aims to internalize the social and environmental costs associated with carbon emissions by assigning a price to each ton of emitted CO_2-equivalent gases (Stavins, 2020). By doing so, carbon pricing incentivizes firms and consumers to reduce their emissions and invest in low-carbon technologies, thereby contributing to climate change mitigation (World Resources Institute [WRI], 2023).

Cap-and-trade is a market-based regulatory mechanism designed to limit total greenhouse gas emissions. Under this system, a regulatory authority sets a cap on the aggregate emissions allowed within a jurisdiction (Center for Climate and Energy Solutions [C2ES], 2024). Emission allowances equal to this cap are allocated or auctioned to firms, which can then buy, sell, or trade these permits (European Commission, 2023). The cap ensures that overall emissions do not exceed a predefined level, while trading provides flexibility and cost efficiency by enabling entities with lower abatement costs to sell allowances to those facing higher costs (Goulder & Schein, 2013).

A carbon tax directly sets a fixed price per ton of CO_2 (or CO_2-equivalent gases) emitted. A carbon tax is a fixed fee levied on the carbon content of fossil fuels or on the volume of greenhouse gas emissions produced (Brookings Institution, 2023). Unlike cap-and-trade systems that set a limit on emissions, a carbon tax directly fixes the price per unit of emissions. This price signal encourages emitters to reduce their carbon output if the cost of abatement is less than the tax, thereby promoting cleaner production methods and technologies (Morris & Johnson, 2024). While a carbon tax offers price certainty, it does not guarantee a specific emissions reduction outcome (WRI, 2023).

The electricity market refers to the framework and processes through which electrical power is generated, transmitted, distributed, and sold. It encompasses a range of participants, including power producers, grid operators, wholesalers, retailers, and consumers (International Energy Agency [IEA], 2023). The structure of electricity markets can be regulated or competitive, and the design significantly influences electricity pricing, investment decisions, and the integration of renewable energy sources (Fuss et al., 2023; Renewables Global Panel, 2024).

Performance in the context of electricity markets and carbon pricing denotes the effectiveness and efficiency with which carbon pricing mechanisms achieve desired outcomes. Key dimensions of performance include the magnitude of emissions reductions, the stability and predictability of electricity prices, impacts on investment in low-carbon technologies, market competitiveness, and the reliability of electricity supply (Fuss et al., 2023; IEA, 2023).

Carbon emissions represent a classic example of a negative externality—costs imposed on society that are not reflected in market prices. Without policy intervention, the market overproduces emissions, leading to environmental degradation (Stavins, 2020).

A carbon tax, first proposed by Arthur Pigou, corrects the market failure by imposing a fee equal to the social cost of carbon (SCC) that affects the electricity market performance. This directly internalizes the externality (Goulder & Schein, 2013). On the other hand, a cap-and-trade system sets a limit (cap) on total emissions and allows firms to trade permits, establishing a market price for carbon through supply and demand (C2ES, 2024). Both aim to reduce emissions, but they differ in terms of price vs. quantity control. Stavins (2020) and Goulder & Schein (2013) highlight that the choice between price and quantity instruments depends on the relative uncertainty and slopes of marginal abatement costs and marginal damages.

Governments set an emissions cap and distribute allowances. Firms that reduce emissions can sell their excess permits, incentivizing cost-effective reductions (European Commission, 2023). By placing a price on carbon and thus correcting the market failure, these systems create an incentive to develop and invest in energy-saving technologies (Renewables Global Panel, 2024). This encourages the shift to a lower carbon economy and takes advantage of market efficiencies (World Resources Institute, 2023). The number of firms directly impacted by these systems can be large or small; most proposals focus on a limited number of firms to maximize emissions coverage while reducing administrative costs (Brookings Institution, 2023). However, by putting a price on carbon, these policies raise concerns about adverse impacts on energy-intensive firms, manufacturing states, and the workers or communities historically dependent on fossil fuels (Morris & Johnson, 2024).

3. METHODOLOGY

This study employs a qualitative comparative analysis (QCA) and a synthesis of empirical case studies to evaluate the relative performance of carbon taxes and cap-and-trade systems within electricity markets. The research utilizes a dual-track approach: first, a theoretical evaluation of market efficiency and price vs. quantity control; and second, an assessment of global policy implementation to identify best practices for economic growth.

3.1. Comparative Framework and Metric Selection

To provide a structured evaluation, the study utilizes a comparative framework based on eleven distinct criteria. These metrics were selected because they represent the primary tensions between environmental goals and economic stability in electricity market regulation:

Environmental and Price Certainty: These are the fundamental trade-offs in climate policy; the study assesses whether a policy prioritizes meeting emission targets (quantity control) or providing predictable investment signals (price control).

Administrative Complexity and Institutional Capacity: These metrics evaluate the "ease of entry" for regulators, acknowledging that market-based trading requires more robust registries and exchanges than fixed-fee taxes.

Market Efficiency (Static and Dynamic): This evaluates the policy's ability to equalize marginal abatement costs across emitters while simultaneously incentivizing long-term innovation in energy-saving technologies.

Political Feasibility and Equity: These metrics address the social dimension of carbon pricing, focusing on regressive impacts and the transparency of revenue recycling, which often determine the longevity of a policy.

3.2. Case Study Selection Criteria

The study adopts a "purposive sampling" method for its case studies, selecting jurisdictions that represent diverse institutional frameworks and geographical contexts to ensure the findings are globally relevant:

The European Union Emissions Trading Scheme (EU ETS): Selected as the primary model for a mature, large-scale cap-and-trade system. It provides critical data on market evolution, permit overallocation, and recent reforms like the Market Stability Reserve.

Sweden’s Carbon Tax: Chosen as the benchmark for a long-term, high-price carbon tax regime (active since 1991). It serves as a longitudinal proof-of-concept that high carbon prices can coexist with sustained economic growth and significant emission reductions.

California’s Cap-and-Trade Program: Included to demonstrate the effectiveness of sub-national "hybrid" models. California’s use of price floors and ceilings (collars) provides a case for how jurisdictions can mitigate the price volatility traditionally associated with trading systems.

Indonesia and Nigeria: These emerging market examples are included to highlight the challenges of Monitoring, Reporting, and Verification (MRV) and the external pressures of international mechanisms like the EU's Carbon Border Adjustment Mechanism (CBAM).

4. RESULTS AND DISCUSSION

Comparative Analysis of Carbon Taxes and Cap-and-Trade Systems

In contrast to quantity-based limits, a carbon tax imposes a fixed levy on the carbon content of fossil fuels, where tax liability scales directly with the volume of emissions produced. This fiscal approach was pioneered by nations such as Norway, Sweden, and Germany to decouple economic activity from greenhouse gas output (Stavins, 2020).

Advantages and Challenges of Cap-and-Trade Systems

The primary strength of the cap-and-trade mechanism lies in its ability to provide high environmental certainty; by establishing a definitive emissions ceiling, regulators can ensure alignment with specific climate targets and international accords (C2ES, 2024). Furthermore, the system promotes cost-effectiveness through market-based trading, where firms with lower marginal abatement costs can sell surplus permits to those facing higher compliance costs, thus minimizing the aggregate cost of reduction across the economy (Goulder & Schein, 2013). This creates a persistent incentive for innovation, as firms are financially rewarded for developing energy-saving technologies that allow them to profit from permit sales (Renewables Global Panel, 2024).

Despite these benefits, cap-and-trade systems face significant implementation hurdles. The most prominent challenge is permit price volatility, which can create a climate of uncertainty for long-term business investments (Stavins, 2020). Additionally, the initial allocation of permits remains a contentious policy choice; free allocation can inadvertently lead to "windfall profits" for heavy emitters, while auctioning may strain industrial competitiveness. Finally, the system requires a sophisticated institutional framework for monitoring and enforcement to ensure that all participants remain within their allocated limits (European Commission, 2023).

The choice between a carbon tax and a cap-and-trade (C&T) system involves fundamental trade-offs between environmental outcomes, economic predictability, and institutional requirements. This section synthesizes these differences across four primary dimensions.

4.1. The Certainty Trade-off: Emissions vs. Price

The most significant distinction between the two mechanisms lies in the type of certainty they offer regulators and market participants. A cap-and-trade system provides high **emission certainty** because the total volume of greenhouse gases is strictly limited by the available allowances. Conversely, a carbon tax offers high price certainty by fixing the cost per ton of CO2, allowing firms to plan long-term capital investments with a predictable "marginal cost of carbon". However, under a tax regime, actual emission reductions are secondary to the price signal and remain subject to the price elasticity of demand within the electricity sector.

4.2. Market Dynamics and Investment Signals

The impact on electricity prices varies significantly by mechanism. Carbon taxes typically result in a predictable increase in electricity costs, whereas C&T systems can introduce price volatility as allowance prices fluctuate based on market supply and demand. While volatility is often viewed as a risk, C&T offers superior market adaptability through "built-in flexibility" mechanisms such as the banking and borrowing of permits. This allows the market to self-adjust; for instance, during economic downturns, reduced demand naturally lowers the carbon price, whereas a tax remains static unless manually adjusted by the government (Chateauet al., 2023).

4.3. Administrative and Institutional Complexity

From an operational perspective, carbon taxes are generally characterized by simplicity and transparency, making them easier to administer through existing fiscal infrastructure. In contrast, C&T systems are inherently complex, requiring the establishment of registries, auctioning platforms, and sophisticated Monitoring, Reporting, and Verification (MRV) systems. This complexity often presents a barrier for developing nations with limited institutional capacity, although it creates a more liquid and transparent market environment for large-scale industrial players.

4.4. Fiscal Impact, Revenue Use, and Political Feasibility

Both systems have the potential to generate significant government revenue, though they do so through different channels. Carbon taxes provide a **predictable revenue stream** that can be used for "revenue-neutral" tax reforms or green infrastructure. C&T systems only generate revenue if allowances are auctioned rather than granted for free; however, free allocation is often used as a tool to increase **political feasibility** by mitigating competitiveness concerns for energy-intensive industries. Despite the theoretical efficiency of taxes, they often face lower political acceptability because they are frequently framed as a direct cost burden on the populace, whereas C&T systems are often viewed as market-driven regulatory tools.

There are important similarities and contract between Carbon Tax and cap-and-trade. These could be summarised as follows (Table 1):

Table 1. Comparison between Carbon Tax and cap-and-trade.

Criteria	Carbon Tax	Cap-and-Trade
Emission Certainty	Low (with price elasticity)	High (emissions capped)
Price Certainty	High (fixed tax rate)	Low (market determined)
Administrative Complexity	Relatively simple	Complex allocation & trading (requires monitoring)
Impact on Electricity Price	Predictable increase	Volatile; depends on allowance price
Investment Signal	Stable pricing; better for planning	Flexible signal; depends on market pricing
Market Adaptability	Less flexible; adjustments needed	Built-in flexibility (banking, etc.)

Criteria	Carbon Tax	Cap-and-Trade
Equity / Fiscal	Generates revenue, more transparent	Revenue only if allowances auctioned
Design Flexibility	Can include mechanisms (e.g., rate increases)	Can include price collars
Revenue Use	Predictable and usable for tax reform	Can be auctioned or freely allocated
Market Efficiency	High if well-calibrated	High if liquid and transparent
Political Feasibility	Often low	Mixed; depends on design

Case Study 1: The European Union Emissions Trading Scheme (EU ETS)

As the world's largest carbon market, the EU ETS provides critical empirical evidence of these dynamics. Although the scheme was initially hindered by overallocation and subsequent price crashes, successive reforms—including the introduction of the Market Stability Reserve—have bolstered its efficiency and environmental integrity (European Commission, 2023). Similar frameworks have since been adopted regionally in the United States and Canada, demonstrating the model's scalability across diverse jurisdictions (IEA, 2023).

The most significant advantage of a carbon tax is the price certainty it provides; a predictable carbon price allows utilities and industrial firms to integrate carbon costs into their long-term capital planning with high precision (Brookings Institution, 2023). Architecturally, the tax model offers simplicity and transparency, as it can often be administered through existing fuel tax infrastructures, avoiding the complexity of permit exchanges (World Resources Institute, 2023). Moreover, it serves as a robust tool for revenue generation. Governments can utilize these funds for "revenue-neutral" reforms—offsetting other corporate or income taxes—or direct them toward green infrastructure and renewable energy subsidies (Morris & Johnson, 2024).

However, carbon taxes are frequently criticized for emissions uncertainty, as they fix the price rather than the quantity; if the tax rate is set too low, it may fail to achieve necessary climate thresholds (Goulder & Schein, 2013). Furthermore, the model often encounters significant political resistance, as it is frequently framed as a direct cost burden on consumers rather than a market regulation. This is compounded by concerns regarding the regressive impact of energy taxes, which can disproportionately affect low-income households unless paired with targeted revenue-recycling or dividend programs (Morris & Johnson, 2024).

Case Study 2: The British Columbia Carbon Tax

Implemented in 2008, British Columbia's carbon tax serves as a benchmark for successful fiscal climate policy. By maintaining a revenue-neutral design—returning proceeds to taxpayers through credits and tax cuts—the province has demonstrated that a carbon tax can reduce emissions without hindering economic growth (WRI, 2023). The success of this case underscores that public communication and careful fiscal design are essential for the social acceptance of carbon pricing (Brookings Institution, 2023).

Case Study 3: Indonesia's Power Sector ETS (2023) – A Hybrid Transition Model

Indonesia's launch of a mandatory, intensity-based Emissions Trading System (ETS) in February 2023 represents a significant milestone for carbon pricing in emerging economies. As the first national ETS in Southeast Asia focusing on the electricity sector, it provides a unique model for balancing aggressive decarbonization goals with the needs of a coal-dependent energy grid.

Mechanism Design: The system is "intensity-based," meaning it sets a limit on emissions per unit of electricity generated (tCO2e/MWh) rather than an absolute cap on total emissions. This design allows for continued economic growth and electricity demand expansion while incentivizing efficiency improvements in coal-fired power plants (CFPPs).

Phased Implementation: Phase 1 (2023–2024) covers 99 grid-connected coal plants accounting for over 80% of national generation capacity. Starting in 2025, the scheme will expand to include "captive" power plants—privately owned facilities that supply industrial users directly—which currently represent a significant "blind spot" in Indonesia's climate strategy.

The "Cap-Tax-and-Trade" Hybrid: Indonesia utilizes a unique hybrid model where the ETS is paired with a fallback carbon tax (slated for 2025). Emitters that exceed their intensity caps must either purchase surplus allowances on the IDXCarbon exchange or pay a carbon tax, the rate of which is intended to be linked to market prices.

Current Performance and Market Efficiency: Initial results from 2023 showed a modest carbon price of approximately USD 2.00–4.00 per tonne, with limited liquidity due to generous initial caps. However, the institutional framework established—including the

APPLE-Gatrik online reporting platform—lays the groundwork for the more stringent caps required to meet Indonesia's 2030 Just Energy Transition Partnership (JETP) targets.

Case Study 4: EU CBAM and the African Energy Landscape: The Case of Nigeria

The implementation of the EU's Carbon Border Adjustment Mechanism (CBAM), which entered its transitional phase in October 2023, introduces a new external pressure on the electricity and industrial sectors of trade partners like Nigeria.

Mechanism and Scope: CBAM functions as a "carbon tariff" on energy-intensive imports to the EU, including cement, iron and steel, aluminum, fertilizers, electricity, and hydrogen. From 2026, importers must purchase CBAM certificates pegged to the weekly average price of the EU ETS, effectively equalizing the carbon cost between EU-based and foreign producers.

Nigeria's exposure primarily lies in its fertilizer (urea) and potentially future hydrogen or steel exports. While CBAM-covered goods currently represent a small percentage of total Nigerian exports, the policy creates a "carbon barrier" that could marginalize industries lacking the financial and technological capacity to decarbonize rapidly.

The "Stepping Stone" Incentive: Critically, CBAM allows for a discount if a carbon price has already been paid in the country of origin. This creates a strong incentive for Nigeria to establish a domestic carbon tax or ETS. By doing so, Nigeria can ensure that carbon revenue remains within the domestic economy to fund its own "Energy Transition Plan" rather than being collected as a tariff by the EU.

However, for Nigerian exporters to comply with CBAM, they must adopt rigorous Monitoring, Reporting, and Verification (MRV) systems for embedded emissions. This requirement highlights a significant institutional gap; however, proactive engagement—such as the services provided by SGS Nigeria—indicates a growing private-sector response to these global carbon standards.

The transition from theoretical carbon pricing to practical implementation reveals significant opportunities for balancing economic growth with environmental efficiency. Following initial start-up challenges in the European Union, such as data gaps and inconsistent national approaches, the EU ETS has established the foundational building blocks for a robust global trading regime, a model now mirrored in North American regional programs and the emerging national market in South Korea (European Commission, 2023; IEA, 2023). Empirical evidence from Sweden's carbon tax—which reached approximately $130/ton by

2024—demonstrates that high carbon prices can coexist with robust economic expansion, as the country achieved a 27% emissions reduction while utilizing revenues to lower distortionary corporate and income taxes (Stavins, 2020; WRI, 2023). Similarly, California's cap-and-trade system has successfully decoupled growth from emissions, with covered sectors seeing a 10% decline in output while the state's economy consistently outpaced national averages (C2ES, 2024).

A critical distinction in market performance lies in how each system responds to economic fluctuations. Cap-and-trade systems function as "self-adjusting" mechanisms; during economic downturns, reduced industrial activity lowers allowance demand and prices, whereas during expansions, market forces naturally drive prices higher to maintain the environmental cap (Goulder & Schein, 2013). In contrast, carbon taxes require manual government intervention to adjust price levels, which can lead to regulatory lag. From an efficiency perspective, both tools aim to equalize marginal abatement costs across emitters, yet they offer different advantages: taxes provide the "static efficiency" of predictable price signals for long-term investment, while trading ensures "dynamic efficiency" by allowing emissions reductions to occur where they are most cost-effective (Morris & Johnson, 2024; Stavins, 2020).

To mitigate the inherent risks of price volatility in trading or emissions uncertainty in taxing, modern policy is increasingly shifting toward hybrid frameworks. The integration of price floors and ceilings in California, alongside the EU's Market Stability Reserve, provides essential investor confidence by preventing extreme price fluctuations (Fuss et al., 2023; IEA, 2023). Furthermore, innovative models such as Canada's "carbon fee and dividend" or output-based pricing systems address political and distributional concerns by returning revenues directly to citizens or protecting trade-exposed industries (WRI, 2023). Ultimately, the successful scaling of these instruments—particularly in developing contexts—depends on robust institutional capacity for Monitoring, Reporting, and Verification (MRV) and international coordination to prevent carbon leakage through mechanisms like the EU's Border Carbon Adjustments (European Commission, 2023; World Resources Institute, 2023).

5. POLICY RECOMMENDATIONS: A HYBRID PATHWAY FOR EMERGING ECONOMIES

Based on the comparative analysis of Indonesia's power sector reform and the impending challenges of the EU's Carbon Border Adjustment Mechanism (CBAM), this study recommends that Nigeria adopt a sector-specific, intensity-based hybrid carbon pricing model as a strategic defensive mechanism. Following the "Indonesia Model," Nigeria should prioritize the implementation of an emissions trading system (ETS) specifically for its electricity generation sector, utilizing an intensity-based cap that allows for grid expansion while incentivizing the displacement of high-carbon "captive" power generation.

Such a framework would directly address the "CBAM risk" by ensuring that carbon costs are internalized domestically; under current EU regulations, any carbon price paid in the country of origin can be credited against CBAM obligations. This "revenue retention" strategy ensures that fiscal resources remain within Nigeria to fund the Energy Transition Plan (ETP) rather than being collected as external tariffs by trade partners. Furthermore, to overcome institutional limitations, the government should leverage the technical standards of the African Continental Free Trade Area (AfCFTA) to establish a unified Monitoring, Reporting, and Verification (MRV) infrastructure. By pairing an initial intensity-based ETS with a fallback carbon tax—similar to Indonesia's "Cap-Tax-and-Trade" approach—Nigeria can provide the long-term price certainty required for renewable baseload investment while shielding its industrial exporters from global carbon barriers.

The Indonesia Model provides the Mechanism: An intensity-based ETS is easier for a developing economy to swallow because it doesn't limit total growth, only carbon "inefficiency." On the other hand, the CBAM Case provides the Urgency: It explains why Nigeria needs to do this now—to keep carbon tax revenue at home rather than letting it go to Europe.

6. CONCLUSION

As the global energy transition accelerates, carbon pricing has transitioned from a theoretical economic concept to an essential regulatory necessity for maintaining electricity market efficiency and international trade competitiveness. This study has evaluated the two primary market-based instruments—carbon taxes and cap-and-trade systems—revealing that while each possesses distinct mechanical advantages, their effectiveness is increasingly dependent on institutional design and market context.

Carbon taxes offer unparalleled price certainty and administrative simplicity, making them an attractive entry point for jurisdictions with established fiscal infrastructure but limited market-trading experience. Conversely, cap-and-trade systems provide the environmental certainty required to meet stringent international climate commitments by placing a definitive limit on total emissions. However, the historical volatility associated with trading permits has led to a significant shift toward hybrid mechanisms. The integration of price floors, stability reserves, and intensity-based caps—as demonstrated by the EU ETS and the Indonesian power sector—represents the current "frontier" of carbon policy, successfully blending the predictability of a tax with the environmental integrity of a cap.

For emerging economies, particularly those in Africa like Nigeria, the implementation of domestic carbon pricing is no longer solely an environmental objective but a strategic trade imperative. The rise of the EU's Carbon Border Adjustment Mechanism (CBAM) introduces a "carbon barrier" that necessitates domestic internalization of emission costs to prevent capital flight in the form of external tariffs. This paper concludes that a sector-specific, intensity-based hybrid model offers the most viable pathway for such economies to balance electricity price stability with the demands of global decarbonization.

Ultimately, the success of these mechanisms hinges on robust institutional capacity, transparent revenue recycling, and a commitment to Monitoring, Reporting, and Verification (MRV). While no single approach is universally optimal, a well-calibrated carbon price—whether a tax, a cap, or a hybrid—remains the most powerful tool for decoupling economic growth from greenhouse gas emissions and fostering long-term investment in a low-carbon future.

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