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Navigating the Green Gold: Opportunities and Challenges of Carbon Credit Implementation in the Indonesian Palm Oil Industry—Lessons from Malaysia

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ABSTRACT: Indonesia, as the world's largest palm oil producer, confronts a critical imperative to decarbonize its oil palm sector while leveraging emerging carbon markets to finance the transition. This qualitative literature review examines opportunities and implementation challenges for deploying carbon credits in Indonesia's palm oil industry, synthesizing Malaysia's strategic experience and international best practices. Drawing from academic journals, policy documents, and industry reports (2020–2025), the study identifies three primary technological pathways—POME (Palm Oil Mill Effluent) biogas capture, biochar production from empty fruit bunches, and biomass energy systems—that generate high-quality carbon credits with promising economic viability. While Indonesia possesses superior scale advantages and targets for climate mitigation (FOLU Net Sink 2030: −140 $MtCO_2e$ by 2030), the country faces regulatory fragmentation stemming from its national registry system (SRN-PPI) and conflicting governance frameworks, which hinder international market access relative to Malaysia's market-friendly approach through the Bursa Carbon Exchange. The research reveals that recent Mutual Recognition Arrangements with Verra and Gold Standard represent critical steps toward harmonization, yet institutional gaps—including inadequate measurement, reporting, and verification capacity; buffer stock requirements; and land rights disputes—continue to impede project development. The paper recommends regulatory harmonization, enhanced technology transfer, a more explicit definition of carbon rights, and increased fiscal incentives for technology-based credits as pathways to unlock Indonesia's estimated 1,283 million tonnes of annual carbon credit potential. This comparative analysis contributes to understanding how developing nations can strategically navigate the voluntary and compliance carbon markets within their agricultural sectors.

KEYWORDS: carbon credits, palm oil, POME, biochar, Indonesia, Malaysia, voluntary carbon market, FOLU, regulatory harmonization, climate finance

JEL Classification: Q12 (Crop Production), Q54 (Climate Change and Related Management Issues), G18 (Government Policy and Regulation), O55 (Asia—Developing Countries)

1. INTRODUCTION

1.1. Background and Global Context

The accelerating climate crisis has positioned the voluntary carbon market (VCM) as a complementary instrument to compliance mechanisms in achieving global decarbonization targets. According to the United Nations Environment Programme's Emissions Gap Report 2025, even if all nationally determined contributions (NDCs) are fully implemented, global average temperatures are projected to rise by 2.5°C above pre-industrial levels—well above the Paris Agreement's 1.5°C and 2°C pathways. Consequently, annual emissions reductions of 35% and 55% (compared to 2019 levels) are required by 2035 to align with these targets. This systemic gap necessitates deploying all available mitigation tools, including carbon credit markets, to mobilize private capital toward emission-reduction technologies while supporting developing countries' climate ambitions(Kreibich, 2024).

The agricultural sector, particularly plantation agriculture, represents both a significant source of global greenhouse gas emissions and an underutilized opportunity for carbon sequestration and removal. Palm oil production alone accounts for approximately 2–3% of global greenhouse gas emissions, primarily from land-use change, biomass decomposition, and energy consumption in processing facilities. Conversely, sustainable palm oil systems offer multiple pathways for carbon abatement: waste valorization, adoption of renewable energy, and enhanced carbon storage through improved agronomic practices. For Indonesia, the world's largest palm oil producer (accounting for ~60% of global supply), the strategic deployment of carbon credits in the sector could simultaneously meet climate obligations under its FOLU Net Sink 2030 target and generate new

revenue streams for plantation operators. This dual mandate—climate action and economic incentivization—underpins the strategic importance of carbon market development in Indonesia's palm oil industry(Prodeo, 2024).

1.2. Problem Statement and Urgency

Indonesia's palm oil industry stands at a critical juncture. While the country holds substantial natural capital advantages—vast plantation areas suitable for carbon credit projects and a production surplus of biomass residues—it lags its regional counterpart, Malaysia, in realizing carbon market value. Malaysia's 2022 establishment of the Bursa Carbon Exchange (BCX), the world's first Shariah-compliant carbon exchange, and its proactive alignment with international standards (e.g., Verra, Gold Standard) have positioned it as a regional leader in carbon markets. Indonesia, conversely, continues to grapple with regulatory fragmentation. Its mandatory national registry system (SRN-PPI) and national certification standard (SPEI—*Sertifikasi Pengurangan Emisi Gas Rumah Kaca Indonesia*) have created a complex governance landscape that, while ensuring sovereign oversight, has inadvertently raised transaction costs and created barriers to international participation(IDXCarbon, 2025).

Three structural challenges compound this gap. First, **regulatory misalignment**: Indonesia's requirement that all projects register with SRN-PPI before accessing international markets creates procedural bottlenecks, in contrast to Malaysia's market-first approach. Second, **implementation barriers**: High buffer requirements (10–20% of credits withheld domestically), inadequate measurement, reporting, and verification (MRV) infrastructure, and uncertainties around carbon rights on plantation concessions deter private investment in capital-intensive carbon projects. Third, **greenwashing risks**: Without stringent standardization and third-party verification aligned with international benchmarks, Indonesian credits risk being perceived as having lower integrity in global markets, reducing their market value and competitiveness (Sari, 2025).

Concurrently, the impending conclusion of Indonesia's 14-year palm oil moratorium (ending in 2025) threatens to accelerate deforestation and plantation expansion, undermining the country's FOLU Net Sink 2030 target of −140 $MtCO_2e$. This convergence of opportunity and risk makes immediate policy action essential. By studying Malaysia's institutional innovations and adapting them to Indonesia's context, policymakers can accelerate the country's carbon market maturation and unlock an estimated 1,283 million tonnes of annual carbon credit potential(Wiguna et al., 2023).

1.3. Research Objectives and Contribution

This qualitative literature review pursues three interconnected objectives:

1. **To synthesize thematic narratives** on carbon credit mechanisms, technological pathways, and market structures in the palm oil sector, drawing from academic literature, policy documents, and industry reports (2020–2025).
2. **To analyze Malaysia's strategic approach** to carbon credit development, including institutional design (Bursa Carbon Exchange), technological priorities (biochar, POME biogas), and international integration (mutual recognition agreements, ASEAN Common Carbon Framework).
3. **To identify transferable lessons and context-specific adaptations** that can guide Indonesia's carbon market policy, balancing climate ambition, regulatory sovereignty, and competitive market positioning.

By adopting a comparative lens, this paper moves beyond descriptive cataloguing of carbon credit technologies to provide actionable strategic insights for policymakers, carbon project developers, and investor communities in Indonesia. The contribution is particularly timely given the recent Mutual Recognition Arrangements (MRAs) Indonesia has signed with Gold Standard (May 2025) and Verra (October 2025), which create new institutional pathways for harmonizing national and international frameworks. Understanding the implications of these MRAs—both opportunities for market opening and risks of regulatory dilution—is critical for Indonesia's carbon market evolution(Green, 2024).

2. LITERATURE REVIEW

2.1. Conceptual Foundations: Carbon Credits in Voluntary and Compliance Markets

Carbon credits represent a quantified unit of greenhouse gas (GHG) mitigation. By international definition, one carbon credit equals one metric tonne of carbon dioxide equivalent (tCO_2e) of GHG removed, reduced, or avoided. The mechanism operates on a simple principle: entities unable or unwilling to reduce their own emissions to targeted levels can purchase credits from projects that have achieved mitigation results, thereby offsetting their residual emissions and contributing to aggregate climate goals (MoF-DGoSA, 2024).

The carbon market ecosystem comprises two distinct architectures. **Compliance markets** operate under regulatory mandates—such as the European Union's Emissions Trading Scheme (ETS), China's national carbon market, or the International Civil Aviation Organization's CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation)—which impose binding emission caps or reduction targets on regulated entities, creating demand for credits as a compliance mechanism. **Voluntary carbon markets** (VCMs), conversely, function through the voluntary

engagement of corporations, financial institutions, and individuals seeking to offset emissions, achieve net-zero commitments, or advance sustainability objectives without regulatory compulsion(DTE, 2007).

In the palm oil sector, voluntary markets currently predominate, although compliance pathways are expanding. CORSIA, in particular, mandates international airlines to offset emissions growth from 2020 onwards, creating significant demand for high-quality agricultural carbon credits from the Global South. The VCM's relevance for Indonesia is substantial: the market traded approximately $2.2 billion in credits globally in 2023, with agricultural and forestry projects representing ~30% of transactional value. For Indonesian palm oil producers, accessing both VCMs and emerging compliance mechanisms requires credits that meet rigorous quality standards and are accepted by international buyers(Purnomo et al., 2025).

2.2. Carbon Credit Quality: Essential Attributes and Verification Standards

The integrity of carbon credits depends on adherence to five core principles, as synthesized by the Integrity Council for the Voluntary Carbon Market's Core Carbon Principles (CCP) (IDXCarbon, 2023).

Additionality requires that GHG reductions or removals would not have occurred in the absence of the project. For POME biogas projects, this means demonstrating that, without carbon revenue, palm mills would not have invested in anaerobic digestion systems; thus, the avoided methane emissions represent genuine additional mitigation. **Permanence** ensures that sequestered carbon remains stored over the long term; for biochar projects using empty fruit bunches, permanence is high (centuries to millennia) because the carbon is chemically recalcitrant in soil, in contrast to tree-planting projects, which have a higher risk of reversal. **Leakage** refers to the displacement of emissions outside project boundaries; for example, if a mill's waste is diverted to biochar production but then sent to uncontrolled dumping elsewhere, the net benefit is reduced. **No double counting** prevents the same emission reduction from being claimed multiple times—a critical issue when projects operate under both national (SRN-PPI) and international (Verra) registries(Astari et al., 2025).

International standards provide the benchmarking framework for credit quality. **Verra** (formerly VCS—Verified Carbon Standard), established in 2007, has issued over 1 billion VCUs globally and is the VCM's largest standard. **Gold Standard**, founded in 2003, emphasizes the co-benefits of sustainable development alongside climate mitigation, attracting ESG-focused buyers. For agricultural projects, both standards require rigorous baseline determination (counterfactual emissions absent the project), conservative justification of additionality, and third-party verification by accredited independent entities. **CORSIA**, while primarily a compliance mechanism for aviation, similarly mandates that credits meet the highest integrity standards, including those validated under Verra or Gold Standard methodologies (Arconesia, 2025).

Indonesia's national standard, SPEI, aligns with the Paris Agreement principles (TACCC: Transparency, Accuracy, Completeness, Comparability, Consistency), but has faced international criticism for its opaque methodology and insufficient third-party independence. The recent MRAs with Verra and Gold Standard represent institutional responses to this gap, enabling dual certification that satisfies both national registry requirements and international market expectations(Purnomo et al., 2024).

2.3. The Malaysian Experience: Market Architecture and Strategic Positioning

Malaysia's carbon market development trajectory offers Indonesia a contemporaneous case study in voluntary market institutionalization. Unlike Indonesia's top-down regulatory approach, Malaysia's strategy has emphasized market incentives, international standardization, and financial innovation(IDXCarbon, 2025).

Institutional Design: The Bursa Carbon Exchange (BCX), launched in March 2023, operates as the trading platform for Malaysia's VCM under the regulatory framework of Bursa Malaysia Berhad, the country's securities exchange operator. Significantly, BCX is the world's first Shariah-compliant carbon exchange, a distinction that opens capital flows from Islamic finance institutions and aligns with Malaysia's positioning as a global Islamic finance hub. The exchange accepts only Verra-standard carbon credits, establishing a clear international benchmark while avoiding the proliferation of multiple standards that can confuse buyers and inflate due diligence costs(CAT, 2025).

Technological Pathways: Malaysia's palm oil decarbonization strategy focuses on waste valorization. Joint research by the Malaysian Palm Oil Council (MPOC), Swinburne University, and Sunway University identified three high-potential carbon credit pathways:

- **POME biogas capture and combustion:** Anaerobic digestion of palm oil mill effluent (POME)—a highly pollutive waste stream containing dissolved solids and methane-generating organics—produces biogas, which can be combusted for electricity or heat. Each mill can avoid 100–500 tCO_2e annually, depending on throughput. Cost-effectiveness is high because POME treatment is already mandated by environmental regulation; carbon credits provide incremental revenue.
- **Biochar from empty fruit bunches:** EFB pyrolysis at 350–400°C yields biochar (36–42% by mass), a carbon-rich soil amendment that permanently sequesters carbon while improving soil quality and

reducing chemical fertilizer needs. Premium global pricing (US$52–113/$tCO_2e$) reflects permanence and co-benefits, with companies such as Google and Microsoft entering into biochar purchase agreements to achieve carbon removal targets(Yoesgiantoro, 2020).

- **Biomass energy systems:** Direct combustion of palm kernel shells (PKS) and other residues in combined heat and power (CHP) systems, replacing fossil fuel energy inputs. This pathway generates avoided emission credits rather than removal credits but exhibits high cost-effectiveness.

International Integration: Malaysia has strategized to position itself at the intersection of regional and global carbon markets. The country has signed memoranda of understanding with South Korea and Singapore to explore Article 6 (Paris Agreement) mechanisms for country-to-country carbon credit transfers. Additionally, Malaysia's leadership in ASEAN's development of the ASEAN Common Carbon Framework (ACCF), launched in 2024, aims to establish interoperable carbon markets across Southeast Asia, thereby further consolidating Malaysia's regional influence and creating economies of scale for carbon project development(CAT, 2025).

2.4. Indonesia's Current Landscape: Regulatory Structure and Recent Developments

Indonesia's carbon market governance has undergone significant evolution, particularly since 2023. The institutional framework rests on several pillars:

National Registry System (SRN-PPI): Established under Presidential Regulation 98/2021 and operationalized through MOEF Regulation 21/2022, the SRN-PPI serves as Indonesia's mandatory registry for all carbon projects, whether pursuing domestic or international trading. This unique feature—making registry participation non-optional—reflects the government's emphasis on sovereign oversight and ensures no carbon credit can escape national accounting. However, it entails additional compliance steps and costs for international project developers (Sari, 2025).

National Certification Standard (SPEI): The Indonesian Greenhouse Gas Emissions Reduction Certification (SPEI), formalized under MOEF Decree SK.1131/2023, is the mandatory standard for carbon projects in Indonesia. SPEI adopts the principles of the UNFCCC Paris Agreement but does not mandate alignment with Verra or Gold Standard methodologies, creating potential divergence in additionality and permanence assessments. This lack of explicit international standardization has been a source of investor hesitation and market skepticism regarding Indonesian credit quality(Yoesgiantoro, 2020).

IDXCarbon (Indonesia Stock Exchange Carbon Platform): Launched in phases between 2023 and 2025, IDXCarbon is Indonesia's voluntary carbon exchange, analogous to Malaysia's BCX. As of 2025, it remains nascent, with limited trading volume and no auctions comparable to those in Malaysia. IDXCarbon is regulated by the Financial Services Authority (OJK) under POJK 14/2023 and requires all traded credits to be listed on SRN-PPI (Rahayu et al., 2021).

Recent Mutual Recognition Agreements: A watershed moment occurred in 2025 with Indonesia's MRAs with Gold Standard (May 2025) and Verra (October 2025). These agreements permit Indonesian palm oil projects to obtain dual certification: registration in SRN-PPI for national accounting purposes and simultaneous certification under Gold Standard or Verra for international market access. Critically, the MRAs establish a two-step process: SRN-PPI registration must precede or occur in parallel with international certification, thereby preserving Indonesia's governance hierarchy while enabling international market participation (Veriasa et al., 2022).

Technological Potential: Indonesia's palm oil biomass availability far exceeds that of Malaysia. The country produces 23% of its total crude palm oil production as waste (EFB and other residues), creating an estimated 1,113.39 MW of biogas potential across 22 provinces. POME biogas projects in Indonesia demonstrate comparable economics to Malaysian projects, with feasibility studies showing NPVs of Rp 21–394 billion and IRRs of 12.84–55%, depending on carbon credit monetization scenarios. Biochar production is technically feasible but faces higher production costs (estimated $70–100/t in Indonesia) and requires the development of domestic carbon credit markets to achieve premiums comparable to global VCM prices(PwC, 2024).

3. METHODOLOGY

3.1. Research Design and Approach

This study employs a **qualitative literature review** methodology, deliberately departing from systematic review protocols to enable thematic synthesis and narrative integration of evidence across heterogeneous source types. A qualitative literature review is particularly suited to policy-oriented research questions that require the interpretation of complex institutional contexts, regulatory landscapes, and strategic dynamics rather than the meta-analytic aggregation of quantitative findings. The approach prioritizes conceptual coherence, interpretive depth, and normative insight over exhaustive systematic coverage(Ichriani et al., 2016).

The research question guiding this review is: *Given Malaysia's demonstrated success in developing carbon markets for its palm oil sector, what opportunities and implementation challenges characterize Indonesia's path to carbon credit monetization, and how can Malaysian lessons inform Indonesian policy within its distinct institutional and geographic context?*

3.2. Information Sources and Selection Criteria

Data collection encompassed five categories of sources published between 2020 and 2025:

1. **Peer-reviewed academic articles** (journals indexed in Scopus or Web of Science) addressing carbon credits, palm oil sustainability, renewable energy in agriculture, and POME management in Southeast Asian contexts.
2. **Government policy documents and regulations:** Indonesian (Presidential Regulations, MOEF decrees, NDC submissions, FOLU Net Sink 2030 operational plans) and Malaysian (Bursa Malaysia directives, KASA guidance, state forestry regulations).
3. **Industry reports and white papers:** From MPOC (Malaysia), GAPKI (Indonesia), PwC, Accenture, and carbon standards organizations (Verra, Gold Standard, ICVCM).
4. **International organization publications:** UNFCCC, UNEP, ITC, FAO reports on carbon markets and agricultural sustainability.
5. **Technical case studies and project documents:** Including verified carbon project documentation from Malaysia and Indonesia, feasibility analyses, and pilot project reports.

Inclusion criteria: Sources directly addressing (a) carbon credit mechanisms, (b) palm oil sector or biomass valorization in Indonesia or Malaysia, (c) regulatory frameworks for carbon trading post-2020, or (d) comparative institutional analysis of carbon markets. Exclusion criteria: Studies focused exclusively on forestry REDD+ projects without agricultural linkages, publications predating 2020 (except seminal methodological standards), and opinion pieces lacking empirical or policy content.

3.3. Analysis Strategy: Thematic Synthesis and Comparative Framework

Data analysis proceeded through iterative thematic coding conducted in two phases:

Phase 1: Inductive coding involved close reading of sources to identify recurring themes, patterns, and conceptual categories without imposing predefined structures. Major themes emerged: (a) technological pathways (POME, biochar, biomass energy); (b) regulatory mechanisms (registries, standards, verification); (c) market structures (compliance vs. voluntary, domestic vs. international); (d) barriers to implementation (financing, land rights, MRV capacity); and (e) policy strategies (harmonization, capacity building, incentives).

Phase 2: Comparative thematic analysis explicitly juxtaposed Malaysian and Indonesian experiences within each theme, identifying points of convergence and divergence. This comparative lens highlighted how Malaysia's market-first, internationally aligned approach contrasts with Indonesia's sovereignty-first, nationally centered approach—a distinction with profound implications for market accessibility and perceptions of credit quality(Purnomo et al., 2024).

The analysis culminated in a synthesis that organized findings into three strategic dimensions: (a) **institutional/governance**, (b) **technological/economic**, and (c) **market/financial**. This multidimensional framing allows recommendations to address different stakeholder audiences (policymakers, project developers, investors).

4. RESULTS: THEMATIC FINDINGS

4.1. Technological Pathways and Carbon Credit Potential

Three primary technological routes for carbon credit generation have emerged as commercially viable in the palm oil sector:

POME (Palm Oil Mill Effluent) Biogas Capture and Utilization: POME is the largest single emission source in palm oil milling, with methane generation in anaerobic treatment ponds accounting for 40–60% of total mill emissions. Biogas capture via covered lagoons or anaerobic digesters converts this waste into electricity or heat, simultaneously avoiding methane emissions and generating renewable energy. Indonesian feasibility studies indicate that a mid-scale mill (processing 50 tons of fresh fruit bunches per day) can avoid 100–150 tCO_2e annually through biogas capture. With carbon credit valuation at US$10–20/$tCO_2e$ in compliance markets or US$5–15 in VCM, annual carbon revenue potential ranges from USD 500–3,000 per mill, which is economically meaningful when aggregated across Indonesia's ~600 active mills. A key advantage is regulatory alignment: POME treatment is already mandated by Indonesian and Malaysian environmental law, making carbon projects effectively "add-on" value streams with minimal incremental capital where treatment infrastructure already exists. However, for mills without existing treatment, capital expenditures (capex) of IDR 50–150 billion (USD 3.2–9.6 million) can be prohibitive without dedicated financing. The Business Model Challenge: In Indonesia, electricity tariffs (PLTA of Rp 1,365/kWh under plant power purchase agreements) may be insufficient to justify capex without carbon revenue, creating dependence on stable carbon prices—a risk during market volatility(Listiningrum et al., 2022).

Biochar Production from Empty Fruit Bunches (EFB): Pyrolysis of EFB at 350–400°C yields biochar products with carbon sequestration permanence measured in centuries to millennia. Technical research demonstrates a yield of 36.92% biochar by mass at 350°C, with net GHG emissions (including process energy) of approximately 0.046 kg CO_2-equiv per kg EFB. The key economic distinction from POME biogas is credit pricing: biochar commands significant premiums in global VCMs due to its permanence and soil co-

benefits (improved water retention, nutrient availability, reduced fertilizer requirements). Global carbon prices for biochar range from USD 52–113/tCO_2e, compared with USD 10–20 for avoided-emission credits. This premium reflects buyer preference for "removal" credits (carbon actually sequestered) over "avoidance" credits (emissions that would not have occurred anyway)—a distinction that has become increasingly important as major corporations face regulatory pressure to demonstrate verifiable carbon removal, not merely offset purchasing (WWF, 2023).

Indonesia's biochar production cost is estimated at USD 70–100/tCO_2e, creating a margin of USD 0–43/tCO_2e at VCM prices—positive but thin. The commercial viability improves when co-benefits are monetized: soil amendment sales (biochar can be sold at USD 200–400/ton when packaged for agricultural distribution) and reduced fertilizer costs provide additional revenue streams. Pilot projects in Sumatra and Kalimantan demonstrate technical feasibility, but market development remains nascent. Malaysia has positioned biochar as a strategic advantage, with MPOC projecting that sustained investment could make Malaysia a regional biochar hub; Indonesia has not yet articulated comparable strategic positioning, leaving this high-value market segment underdeveloped(Astari et al., 2025).

Biomass Energy Systems (PKS and Fiber Combustion in CHP): Palm kernel shells (PKS) and empty fruit bunch fiber represent ~13% of total palm oil plantation output. When combusted in combined heat and power (CHP) systems to replace fossil fuel energy inputs, they avoid emissions from coal or natural gas combustion. Economics are favorable when mills face high electricity costs; the avoided-emission credit value (USD 10–20/tCO_2e) supplements electricity-generation revenue. However, this pathway generates "avoidance" rather than "removal" credits, making them less attractive to buyers seeking verifiable carbon removal and potentially more vulnerable to baseline and additionality disputes(Prodeo, 2024).

Synthesis on Technology: Malaysia's strategic focus on POME and biochar reflects deliberate positioning toward premium, defensible credit pathways. Indonesia, with 5–10 times Malaysia's plantation area, possesses vastly greater absolute-volume potential but has not yet developed a comparable technological focus or market differentiation. This represents a missed strategic opportunity: Indonesia could dominate global biochar carbon markets if it developed supply chains, certification infrastructure, and buyer relationships—yet no major Indonesian consortium has mobilized around this objective.

4.2. Regulatory and Institutional Comparative Analysis

Malaysia's Market-First Approach:

Malaysia's regulatory framework for carbon markets is notably permissive and market-enabling. At the federal level, no comprehensive carbon market regulation existed until the establishment of Bursa Malaysia in 2022; instead, the market developed through Securities Commission guidance and general contract law. This created rapid entry and flexibility. The BCX operates under a simple mandate: accept only Verra-certified credits and facilitate trading on a transparent platform. No complex registry requirements, no dual certification mandates, no buffer withholding—participants can trade credits freely once Verra certification is obtained. This streamlined architecture has enabled rapid market development. Notably, Malaysia's state-level regulations (e.g., Sarawak's forestry rules) permit additional innovation beyond federal restrictions, creating regulatory pluralism that encourages experimentation (Listiningrum et al., 2022).

The Bursa Malaysia approach also leveraged Islamic finance principles (Shariah compliance) as a market differentiator rather than a regulatory constraint. The 2022 Shariah ruling by Malaysia's Securities Commission declared carbon credits as Shariah-compliant, tradable rights, thereby opening flows from Islamic financial institutions, sukuk issuers, and religiously motivated investors. This regulatory innovation—rather than a limitation—expanded market participation.

Indonesia's Sovereignty-First Approach:

Indonesia's framework reflects a contrasting philosophy: national sovereignty and comprehensive oversight. SRN-PPI registration is mandatory for all projects, creating a single national choke point. SPEI certification is mandated domestically, and international standards (Verra, Gold Standard) are voluntary supplements, not primary pathways. This architecture preserves government control but imposes costs: additional documentation requirements, longer approval timelines (typically 3–6 months for SRN-PPI registration), and the potential for regulatory interpretation divergence (Purnomo et al., 2024).

The rationale is defensible: Indonesia's history of deforestation, concession overlap disputes, and governance challenges justify heightened oversight. Yet the practical effect is that Indonesian carbon credits have struggled to gain international acceptance, investor confidence, and market liquidity relative to Malaysian credits, which carry the Bursa Malaysia and Verra brands.

The 2025 MRAs with Verra and Gold Standard represent a critical policy inflection. By enabling dual certification—SRN-PPI registration plus international standard certification in parallel—Indonesia has moved toward a **coordination model** that preserves sovereignty while facilitating international market access. This is a significant improvement from the previous sequential requirement (SRN-PPI first, then international). However, the effectiveness of the MRA depends on implementation: if SRN-PPI approval remains a bottleneck (slow decision timelines, unclear criteria), the parallel track advantage dissolves(Green, 2024).

4.3. Opportunities for Indonesia

Scale Advantage: Indonesia's most significant structural advantage is its large-scale plantation sector. With more than 16 million hectares of palm oil plantations (compared to Malaysia's ~5.5 million hectares), Indonesia can generate 3–5 times the absolute volume of carbon credits at comparable per-hectare yields. If only 30% of Indonesian mills implement POME biogas capture, annual credit generation could exceed 20 million tCO_2e, equivalent to a revenue potential of USD 200–400 million at VCM prices. This scale attracts aggregator models in which carbon credit platforms aggregate small-project credits into larger tranches suitable for institutional buyer procurement (Dahlan et al., 2022).

FOLU Net Sink 2030 Alignment: Indonesia's NDC target of −140 $MtCO_2e$ in the FOLU sector by 2030 creates a quantified policy demand for carbon credits. Unlike Malaysia, which has not committed to specific plantation-level carbon targets, Indonesia's FOLU target provides regulatory certainty that carbon credits will remain policy-relevant through 2030. This creates stability in incentives for long-term project financing(Elieser et al., 2025).

Emerging Finance Mechanisms: Indonesia's development as a leverage point for climate finance is advancing. The recent Mutual Recognition Agreements with Verra and Gold Standard explicitly reference CORSIA compatibility and Article 6 (Paris Agreement) integration pathways. This positions Indonesian palm oil carbon credits as eligible for use in emerging international carbon credit trading mechanisms expected to scale substantially post-2025. Conversely, Malaysia's BCX remains primarily a domestic platform with limited CORSIA integration, which may disadvantage Malaysian credits as compliance demand accelerates(Veriasa et al., 2022).

Untapped Biochar Markets: Indonesia has not yet developed biochar as a strategic carbon product category, despite favorable conditions (low production costs at scale, abundant EFB feedstock, agronomic suitability). If Indonesia were to develop a coordinated biochar value chain—including standardized production (ISO-equivalent certification), buyer aggregation, and market development—it could capture significant global VCM premiums currently dominated by U.S. and Australian biochar providers(WWF, 2023).

4.4. Implementation Challenges for Indonesia

Regulatory Complexity and Bottlenecks:

Despite the 2025 MRAs, Indonesia's regulatory framework remains more complex than Malaysia's. The parallel registration process (SRN-PPI and Verra/Gold Standard simultaneously) has not yet demonstrated equivalency in approval timelines or decision clarity. Project developers report uncertainty regarding SRN-PPI approval and approval windows of 4–8 months, in contrast to Malaysia's Verra certification (2–3 months). Additionally, the requirement that projects register with SRN-PPI *before* completing international certification creates a coordination problem: SRN-PPI reviewers evaluate projects against SPEI criteria, which may diverge from Verra/Gold Standard additionality or permanence thresholds, potentially creating regulatory misalignment(TFA, 2023).

Buffer and Withholding Requirements:

Indonesia's SRN-PPI system imposes a domestic buffer requirement: up to 20% of issued credits are withheld from trading to address monitoring and permanence risks or to offset regulatory surplus. This is substantially higher than international standards (Verra typically requires 2–5% buffers) and markedly higher than Malaysia's zero-buffer policy for Bursa Malaysia-traded credits. From a project investor's perspective, a 20% yield loss immediately reduces IRR by 200–300 basis points for high-margin projects, rendering marginal projects financially unviable. This buffer requirement is justified on sustainability grounds (as a precaution against over-crediting) but functions as a de facto disincentive to carbon project development in Indonesia relative to competing jurisdictions (Sari, 2025).

Land Rights and Concession Disputes:

A foundational challenge in Indonesian carbon projects is the lack of clarity around carbon rights. Plantation concessions (HPH/HGU) often feature overlapping claims, disputed boundaries, and unresolved land-use rights disputes with indigenous communities and local governments. Carbon rights are legally subordinate to land-use rights: a corporation cannot sell carbon credits for land it does not legally control. Indonesia's land registry system (PTSL) has achieved significant improvements in coverage, but disputes remain prevalent in remote plantation areas, particularly in Kalimantan and Sumatra. Malaysia has experienced fewer concession disputes due to more developed land governance systems and earlier plantation consolidation. For Indonesian carbon project developers, conducting due diligence on carbon rights can take 3–6 months and require specialized legal expertise, creating cost barriers, particularly for smaller mills(Gree-Energy, 2024).

Measurement, Reporting, and Verification (MRV) Capacity Gaps:

Indonesia has only four accredited independent verifiers under its national system (PT Mutuagung Lestari, PT Superintending Company of Indonesia, and two others), compared to dozens in Malaysia and globally. This limited capacity creates bottlenecks: projects queue for verification appointments, timelines extend, and verification costs remain high due to limited competitive supply. Additionally, many Indonesian verifiers lack specialized expertise in agricultural carbon projects, requiring expensive international expert engagement. Malaysia has invested more substantially in developing domestic verification capacity, reducing costs and

accelerating timelines for Malaysian projects(Purnomo et al., 2024).

Carbon Pricing Inadequacy:

Indonesia's current carbon pricing is set at IDR 30,000/tCO_2e (approximately USD 2/tCO_2e) under its compliance carbon market framework. This price is far below VCM prices (USD 5–20 for avoidance credits, USD 52–113 for removal credits) and insufficient to incentivize private investment in carbon projects absent additional subsidies. While VCM transactions are legally separate from compliance pricing, the low compliance carbon price signals the government's willingness to accept low-carbon valuations, potentially creating an expectational anchor that depresses VCM credit prices offered to Indonesian projects. Malaysia's BCX does not have an explicit government-set floor price; instead, market dynamics (buyer demand for quality credits) determine pricing, resulting in higher effective prices for high-quality credits (CAT, 2025).

Technology and Capacity Building Gaps:

Biochar production, in particular, requires specialized equipment, operational expertise, and quality-control systems that have not yet been developed at a commercial scale in Indonesia. Malaysia has initiated pilot-scale biochar projects in partnership with universities to build domestic technical capacity. Indonesia lacks a comparable institutional commitment to the development of biochar technology. Similarly, POME biogas systems require technical skills in anaerobic digestion operations, biogas safety management, and grid connection procedures—capabilities that have developed in Malaysia over decades of biomass energy adoption but remain nascent in Indonesia (Tang et al., 2025).

5. DISCUSSION AND SYNTHESIS

5.1. The Sovereignty-Market Tradeoff: Regulatory Philosophy and Outcomes

Malaysia and Indonesia represent two polar positions in the regulatory architecture for carbon markets. Malaysia's approach can be characterized as **market-coordinating**: government establishes the trading platform and accepts international standards, then steps back to allow market dynamics to govern pricing, participation, and credit allocation. Indonesia's approach is **governance-coordinating**: government maintains direct oversight of all projects, mandates domestic certification, and preserves authority to withhold credits or modify rules based on national sustainability objectives(IDXCarbon, 2025).

Each approach has merit. Malaysia's market-first approach accelerates market development, attracts private investment, and benefits from international pricing efficiency. However, it creates potential vulnerabilities: if VCM credit quality deteriorates globally (due to greenwashing or methodological laxity), Malaysian credits traded on BCX could be contaminated by association. Additionally, Malaysia's lighter regulatory touch means less direct government control over which projects are developed, potentially allowing projects with weak local community benefits or environmental integrity(Listiningrum et al., 2022).

Indonesia's governance-first approach preserves national control and enables the country to prioritize projects aligned with FOLU Net Sink 2030 targets and local community interests. However, it imposes compliance costs on project developers and creates market friction. The critical question for Indonesia is not whether to adopt Malaysia's model wholesale, but whether its regulatory burden can be reduced without sacrificing oversight. The 2025 MRAs suggest a potential answer: **parallel coordination**, in which SRN-PPI provides national accountability while Verra/Gold Standard provides international credibility, thereby reducing the need for redundant documentation if registry interoperability improves(Green, 2024).

5.2. Technology and Economic Viability: Toward High-Integrity Carbon Products

The literature reveals a critical divergence in technology strategy. Malaysia has oriented its carbon credit portfolio toward removal-based pathways (biochar) and avoided-emissions pathways (POME biogas, biomass energy) that offer defensible, permanent climate benefits. Indonesia, conversely, remains focused mainly on avoided-emissions credits with lower permanence guarantees. This distinction matters profoundly for market positioning(Tang et al., 2025).

Globally, carbon buyer preferences have shifted markedly since 2020 toward **carbon removal** over carbon avoidance. This reflects several factors: (a) the realization that avoidance-based offsets (REDD+, improved forest management) are vulnerable to permanence risks and leakage (displaced deforestation), and (b) the Paris Agreement's emphasis on reaching net-zero, which requires actual carbon removal from the atmosphere, not merely avoided future emissions. Tech companies (Google, Microsoft), financial institutions (JPMorgan, Bank of America), and climate-committed corporations increasingly commit to carbon removal targets, creating premium VCM demand for removal credits priced at USD 50–200/tCO_2e(Putra Agus Pratama et al., 2024).

Indonesia's biochar potential positions it to capture this emerging market segment. If Indonesia were to develop 100–200 pilot biochar projects over 2025–2028, demonstrating permanence, soil benefits, and market scalability, it could establish a 5–10 year first-mover advantage in Southeast Asian biochar carbon markets. Conversely, maintaining focus exclusively on avoidance-based POME biogas credits leaves Indonesia competing for lower-margin, commoditized VCM segments where price competition from other jurisdictions (Vietnam, Thailand) will intensify(Mahardika, 2022).

Economic Viability Analysis: The feasibility of Indonesian palm oil carbon projects depends critically on scale. A mid-

scale mill (50 t/day capacity) implementing POME biogas can achieve an IRR of 12–15% with carbon credit revenue at USD 10/tCO_2e. For biochar, a 1,000 t/year production facility requires approximately USD 2–3 million in capital expenditure and can achieve an 8–12% IRR at USD 80/tCO_2e VCM prices, with upside from soil amendment sales. These returns are adequate to attract project finance from development finance institutions (IFC, FMO, ADB) if the enabling conditions are in place (clear carbon rights, regulatory certainty, verified buyer pipelines). However, the marginal project falls below investment hurdle rates in the absence of carbon credit revenue, underscoring the carbon price sensitivity of project viability(IESR, 2024).

5.3. Quality Assurance and Greenwashing Mitigation

A persistent critique of voluntary carbon markets is the risk of "greenwashing"—companies purchasing low-integrity offsets to claim climate action while continuing to emit high levels. This critique is particularly salient for agricultural carbon projects, where baselines are difficult to establish, and additionality is contested. Indonesia's focus on stringent governance and oversight can be reframed as a **quality-assurance strategy: by maintaining SRN-PPI oversight and requiring dual certification, Indonesia ensures that credits bearing the "Made in Indonesia" branding meet high integrity standards, thereby** differentiating them in global markets(SNV, 2009).

The Core Carbon Principles (CCP) by the Integrity Council for the Voluntary Carbon Market provide an independent quality benchmark. CCP assesses carbon credits across dimensions, including governance quality, robustness of additionality, permanence monitoring, and sustainable development impact. Indonesian credits that undergo both SRN-PPI review and Verra/Gold Standard certification effectively pass two independent quality gates, potentially supporting premium VCM pricing compared with single-standard credits (Unsomsri et al., 2026).

However, this quality advantage is realized only if the messaging is effective. Indonesia should invest in market education to communicate the dual-certification advantage to corporate buyers, explicitly contrasting "Indonesia-verified, internationally-certified" credits with lower-scrutiny alternatives. Malaysia has pursued this branding strategy implicitly through the BCX platform and Shariah-compliance messaging; Indonesia has not yet developed comparable brand positioning(Kasri & Harun, 2022).

5.4. Climate Finance and Additionality in the Context of NDC Achievement

A final consideration concerns the relationship between carbon credit revenues and Indonesia's FOLU Net Sink 2030 target. Conceptually, carbon credits monetize emissions reductions achieved in service of the NDC. However, there is a potential perverse incentive: if palm oil producers implement carbon projects primarily for credit revenue, not for underlying sustainability improvement, and if those credits are subsequently used by foreign corporations to offset continued fossil fuel emissions, the net climate benefit may be negative from a global perspective (carbon market gaming)(WWF, 2023).

Indonesia's governance-first regulatory approach mitigates this risk by requiring that carbon projects comply with national sustainability criteria, rather than merely international standards. For example, projects must comply with ISPO (Indonesian Sustainable Palm Oil) certification, which mandates environmental and social standards beyond carbon metrics. Malaysia's lighter regulatory approach provides less direct leverage over project selection, although Bursa Malaysia's exclusive reliance on Verra credits indirectly ensures some compliance with sustainability standards (Pasaribu, 2025).

The deeper issue is methodological: ensuring that carbon credits issued represent genuine NDC progress. If Indonesia issues carbon credits for POME biogas projects that would have been implemented anyway (insufficient additionality), those credits inflate apparent progress toward the −140 MtCO_2e FOLU target without representing real additional mitigation. Indonesia's SRN-PPI system includes an additionality review, but the criteria have been criticized as permissive. Strengthening additionality assessment—potentially by adopting Verra's conservative financial additionality tests—would help ensure that credits reflect genuine NDC achievement, though at the cost of slower project approval timelines (IESR, 2024).

6. POLICY RECOMMENDATIONS

6.1. Toward Regulatory Harmonization

Based on the comparative analysis, Indonesia should pursue a **strategic alignment without a convergence** approach: adopt Malaysia's market-enabling principles while preserving governance elements suited to Indonesia's institutional context.

Recommendation 1.1: Accelerate MRA Implementation and Expand Mutual Recognition Pathways

The 2025 MRAs with Verra and Gold Standard are critical institutional innovations. However, their effectiveness depends on seamless implementation. Indonesia should:

- Establish clear SRN-PPI approval timelines (target: ≤60 days) and publish approval criteria to reduce regulatory uncertainty.
- Create an automated registry-to-registry data exchange between SRN-PPI and Verra/Gold Standard registries to reduce administrative burden on project developers.
- Extend MRAs to include Islamic finance-qualified pathways (e.g., Shariah-compliant carbon credits using Bursa Malaysia-style certification) to align

with Indonesia's Islamic finance development objectives.

- Pursue tripartite MRAs involving Indonesia, Malaysia, and ASEAN institutions to enable recognition of palm oil carbon credits across the region, supporting the ASEAN Common Carbon Framework.

Recommendation 1.2: Reduce Buffer and Withholding Requirements

The 20% domestic buffer requirement substantially reduces project IRR and competitiveness relative to non-Indonesian investments. Indonesia should:

- Conduct a technical review of buffer adequacy using VCM-standard risk assessment methodologies (e.g., Verra's non-permanence risk analysis for agricultural projects).
- Reduce domestic buffer to 5–10%, aligned with international standards, with explicit documentation of risk assumptions.
- Establish a buffer release mechanism: if multi-year monitoring demonstrates stable project performance and no additionality disputes, buffers can be gradually released to project holders.

6.2. Technology Prioritization and Development

Indonesia should strategically elevate biochar and other removal-based carbon products to parity with avoidance-based POME biogas credits.

Recommandation 2.1: Establish a National Biochar Development Initiative

- Create a consortium involving GAPKI (palm oil association), academic institutions (IPB, UNAIR), and development finance institutions to develop standardized biochar production protocols, quality assurance, and market development pathways.
- Target 50–100 pilot biochar projects across major palm oil regions by 2028, with government co-financing of capital costs (30–40% subsidy) offset by VCM revenue recapture agreements.
- Develop Indonesia Biochar Standard (IBS) aligned with Verra and ISO specifications, establishing Indonesia as a global biochar quality benchmark.

Recommendation 2.2: Enhance POME Biogas Market Through Aggregation

- Establish a national POME carbon credit aggregation platform (e.g., a dedicated SPV or cooperative structure) to bundle small-mill biogas credits into institutional-scale tranches (100,000+ tCO_2e annually).
- Implement renewable energy tariffs (feed-in tariffs or guaranteed power purchase agreements) that provide downside protection for mill operators, reducing dependency on volatile carbon prices.
- Support 200+ mills in POME biogas implementation through performance-based financing from development banks (IFC, ADB, World Bank) backed by carbon credit revenue.

6.3. Institutional Capacity Building

Recommendation 3.1: Expand MRV and Verification Capacity

- Accredit 15–20 additional independent verifiers by 2027 through competency-based training programs and international partnerships.
- Establish regional MRV centers (Sumatra, Kalimantan, Sulawesi) to reduce verification timelines and enable quality control.
- Develop Indonesian-language guidance on agricultural carbon methodologies to reduce reliance on expensive international expert consulting.

Recommendation 3.2: Clarify Carbon Rights and Land Governance

- Complete land registry coverage (PTSL) in all major palm oil regions, with explicit documentation of carbon rights allocation on concessions.
- Establish dispute resolution mechanisms for overlapping carbon rights claims, ensuring clarity and investment certainty.
- Require baseline carbon rights audits (conducted by accredited verifiers) as a prerequisite for SRN-PPI registration, eliminating post-issuance disputes over credit legitimacy.

6.4. Market Development and Pricing Signals

Recommendation 4.1: Enhance Carbon Price Signals

- Gradually increase the compliance carbon tax from IDR 30,000/tCO_2e toward USD 10–15/tCO_2e (IDR 150,000–225,000) over 3 years, creating VCM price floors that support project investment.
- Implement government procurement of Indonesian carbon credits for FOLU Net Sink 2030 accounting, creating demand certainty.
- Explore revenue recycling mechanisms: dedicate carbon tax revenues to subsidizing technology deployment (POME biogas equipment, biochar production facilities), creating a virtuous cycle where carbon pricing revenue funds emissions reduction investments.

Recommendation 4.2: Position Indonesia in CORSIA and Article 6 Markets

- Align SRN-PPI procedures with CORSIA Eligible Emissions Units (CEEU) standards to ensure Indonesian credits can access aviation sector demand.
- Engage in Article 6.2 bilateral negotiations with major trading partners (South Korea, Japan, EU) to

establish carbon credit trading frameworks that recognize Indonesian credits.

- Develop a marketing strategy positioning Indonesian palm oil carbon credits as high-integrity, verified products with dual SRN-PPI and international certification, differentiating from lower-scrutiny alternatives.

6.5. Comparative Summary and Indonesia's Distinct Path

In synthesizing the comparative analysis, several conclusions emerge:

1. **Malaysia's Institutional Model (Market-Coordinating) Strengths:**
   - Rapid market development and private investment attraction
   - International buyer acceptance and price competitiveness
   - Lower transaction costs and regulatory burden

   Weaknesses:
   - Limited direct government control over project sustainability alignment
   - Vulnerability to VCM integrity crises affecting BCX's reputation
   - Smaller scale limits absolute mitigation impact
2. **Indonesia's Institutional Model (Governance-Coordinating) Strengths:**
   - National oversight ensuring alignment with FOLU Net Sink 2030
   - Potential for quality assurance through dual certification
   - Leverage over project sustainability outcomes

   Weaknesses:
   - Regulatory complexity is deterring investment
   - Higher transaction costs and approval timelines
   - Market skepticism regarding credit quality due to limited international integration
3. **Indonesia's Optimal Path Forward:**

   Indonesia should not adopt Malaysia's model but instead pursue a **third way: coordinated market engagement**. This approach leverages the 2025 MRAs as institutional infrastructure enabling simultaneous national governance and international market access. Key elements:
   - Maintain SRN-PPI oversight for national climate accounting integrity
   - Streamline SRN-PPI procedures to achieve Malaysia-equivalent approval timelines
   - Fully operationalize parallel certification with Verra/Gold Standard, treating international standards as complementary, not subordinate
   - Invest heavily in biochar and removal-based technologies, differentiating Indonesia's carbon product portfolio from Malaysia's avoidance-focused offerings
   - Develop indigenous financing mechanisms (green bonds, sukuk) for carbon projects, reducing dependency on international development finance

This third-way approach leverages Indonesia's scale advantages (16M hectares vs. Malaysia's 5.5M) and technological potential (biochar) while preserving the governance legitimacy and climate-impact assurance that characterize Indonesia's regulatory approach. Successfully implementing this strategy over 2025–2030 could position Indonesia as Southeast Asia's leading palm oil carbon credit producer, generating USD 2–4 billion in annual carbon revenues while advancing FOLU Net Sink targets.

7. CONCLUSION

The global carbon market has matured substantially since the Paris Agreement's inception, yet significant untapped potential remains in the agricultural sectors of developing countries. Indonesia's palm oil industry exemplifies this opportunity-challenge nexus: the world's largest palm oil producer possesses vast biomass resources, proven decarbonization technologies, and a strong policy commitment to emissions-reduction targets, yet faces regulatory and institutional barriers that have constrained market development relative to regional peers.

Malaysia's demonstrated success in establishing the Bursa Carbon Exchange, cultivating high-integrity technology pathways (biochar, POME biogas), and integrating with international standards offers valuable strategic lessons. Yet Malaysia's model—with its market-coordinating philosophy and lighter regulatory touch—may not be optimal for Indonesia's institutional context. Instead, Indonesia should chart a distinct path that preserves sovereign governance while embracing international market integration, leveraging the institutional innovations embodied in its 2025 Mutual Recognition Arrangements with Verra and Gold Standard.

Three transformative priorities emerge from this analysis:

First, institutionalize governance-market coordination by operationalizing MRA. The gap between MRA signature and effective implementation is typically 12–24 months. Indonesia should establish clear implementation roadmaps, reduce SRN-PPI approval bottlenecks, and create registry interoperability to realize the parallel certification benefits promised by MRAs. Success here could position Indonesian carbon credits for rapid growth in CORSIA and Article 6 compliance markets anticipated in the post-2025 period.

Second, strategic technology differentiation through the development of the biochar market. Indonesia's biochar potential is orders of magnitude greater than Malaysia's, yet it remains underdeveloped strategically. By establishing pilot production capacity, creating quality standards, and developing buyer relationships before competing jurisdictions scale up, Indonesia can secure a dominant regional position in removal-based carbon credits—the fastest-growing VCM segment. This requires coordinated intervention across research, infrastructure, and market development, not laissez-faire market dynamics.

Third, pragmatic institutional reform balancing sovereignty and market access. Regulatory complexity is Indonesia's primary competitive disadvantage. By reducing buffer withholding requirements, expanding verification capacity, clarifying carbon rights, and maintaining transparent approval timelines, Indonesia can match Malaysia's operational efficiency while preserving governance oversight. This is not a regulatory race to the bottom but a strategic simplification focused on removing unnecessary friction.

The window for action is narrow. With the palm oil moratorium ending in 2025 and FOLU Net Sink 2030 targets tightening, Indonesia's carbon market infrastructure must mature quickly to incentivize sustainable production patterns before renewed deforestation for plantation expansion. Simultaneously, the global implementation of CORSIA and the emergence of the Article 6 market create unprecedented demand for high-quality agricultural carbon credits. Indonesia can meet both imperatives—advancing NDC targets while generating climate finance—if it executes the regulatory and technology investments outlined above.

The choice is not between Malaysia's model and status quo, but between strategic adaptation and lost opportunity. Indonesia possesses the scale, resources, and policy commitment to become the world's leading producer of palm oil carbon credits. Realizing this potential requires learning from Malaysia's institutional successes while developing mechanisms tailored to Indonesia's governance philosophy and economic context.

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