Indonesia's Steel Industry and Decarbonization Roadmap: Leveraging Nickel Resources for Sustainable Growth

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Abstract

This study analyzes Indonesia's steel sector within the context of its national net-zero emissions pledge by 2060, emphasizing the integration of abundant nickel resources with emerging decarbonization technologies. As a rising global steel producer with 17 million tonnes of crude steel output in 2024 (ranking 14th worldwide), Indonesia faces the dual challenge of fueling infrastructure-led growth while curbing emissions from its expanding industry. Drawing on recent policy developments, including the 2025 Industrial Decarbonization Roadmap, the analysis highlights three key levers: scrap-based electric arc furnace (EAF) expansion, green hydrogen adoption, and carbon capture, utilization, and storage (CCUS) deployment. Indonesia's state-driven industrial policy, coordinated across ministries, positions the country as a potential green steel hub in Southeast Asia, contrasting with resource-constrained models elsewhere. Insights are triangulated from policy documents, industry reports, and AI-assisted scenario modeling, underscoring opportunities for international collaboration in technology transfer and trade.

1 Introduction

Indonesia's steel industry is pivotal to its vision of becoming a high-income economy by 2045 under the "Golden Indonesia 2045" framework. With crude steel production reaching 17 million metric tons (mt) in 2024—a modest 0.9However, rapid expansion amplifies environmental pressures: the sector emits around 30-35 million mt of CO_2 annually, accounting for 5-7In contrast to China's state-coordinated mega-scale approach or the EU's multi-level governance, Indonesia's model blends resource nationalism (e.g., nickel downstreaming bans on raw exports) with pragmatic green incentives. This paper employs a mixed-methodology—policy mapping via AI tools (e.g., Grok for scenario synthesis) and expert validation—to dissect the architecture, implementation realities, and global implications of Indonesia's steel decarbonization strategy.

2 Methodological Approach: AI-Enhanced Policy Analysis

The analysis integrates large language models for rapid policy scanning and scenario projection, grounded in metallurgical expertise. Key tools include:

- **Grok (xAI)**: For synthesizing roadmap scenarios, regional implementation variations, and international benchmarking.
- **Secondary Sources**: Government roadmaps, IEA/UNIDO reports, and industry data for validation.

Outputs are cross-verified against real-world pilots, ensuring a balance between aspirational targets and feasible pathways. This hybrid approach addresses data gaps in emerging markets like Indonesia, where policy literature on steel decarbonization remains nascent [2].

3 Indonesian Policy Architecture: A Resource-Driven Framework

Indonesia's steel governance operates under a centralized yet incentive-based structure, led by three core ministries:

- **Ministry of Industry (Kemenperin)**: Oversees production capacity, technology standards, and downstreaming policies (e.g., 2020 nickel ore export ban to boost domestic smelting).
- **Ministry of Energy and Mineral Resources (ESDM)**: Manages raw material supply chains, including iron sand exploration and green hydrogen certification.
- **Ministry of Environment and Forestry (KLHK)**: Enforces emissions standards and CCUS regulations under the 2021 CCUS Law.

The policy hierarchy cascades from national plans to sector-specific instruments:

1. **National Commitments**: The 2025-2045 National Medium-Term Development Plan (RPJMN) embeds steel decarbonization within the Just Energy Transition Partnership (JETP), securing $20 billion in international fin$

1. **Sector Directives**: The Industrial Decarbonization Roadmap mandates 50
2. **Implementation Tools**: Tax incentives for green investments (e.g., 30
3. **Supporting Ecosystems**: Renewable energy targets (23

4 Three Operational Pillars of Steel Decarbonization

4.1 Pillar 1: Scrap-Based EAF Expansion and Circular Economy

Indonesia's steel mix is EAF-dominant (60-70

- **Targets**: Increase scrap use to 15-20 million mt annually by 2030, reducing emissions to 0.4-0.5 tCO_2/t steel (vs. 2.0 for BF-BOF).
- **Initiatives**: National scrap collection networks, supported by WTO-compliant recycling incentives post-2025 stainless steel dispute resolution [8].
- **Challenges**: Tramp elements in scrap degrade quality; policies promote advanced sorting via AI-driven facilities.

4.2 Pillar 2: Green Hydrogen Integration

Leveraging cheap solar/wind (potential 3,000 GW), Indonesia pilots hydrogen-DRI-EAF:

- **Pilots**: Krakatau Steel's collaboration with Pupuk Indonesia for 100,000 t/y green H_2 by 2027; IESR-backed market-building for exports to Japan/Korea [5].
- **Policy Support**: Presidential Regulation 112/2022 certifies green H_2, targeting 1 GW electrolysis capacity by 2030.
- **Realities**: Costs ($3 - 5/kgH_2$) hinge on RE scaling; regional hubs in Sulawesi (nickel belt) minimize logistics.

4.3 Pillar 3: CCUS as a Bridge Technology

With 151 Tcf of CO_2 storage potential, CCUS captures 20-30

- **Projects**: Tangguh CCUS (2026 startup, 2 Mt/y capacity) and Gundih (gas processing integration); steel-specific pilots at Krakatau Cilegon [9].
- **Framework**: 2021 CCUS Law enables hub-and-spoke models, attracting Asian investors for transboundary storage.
- **Implementation**: Focus on utilization (e.g., CO_2 for enhanced oil recovery), offsetting costs amid high upfront investments ($50 - 100/tCO_2$ avoided).

5 Geographical Implementation: Regional Resource Synergies

- **Nickel Belt (Sulawesi, Maluku)**: Downstream hubs for stainless steel, integrating green H_2 with RE-rich grids.
- **Java Industrial Corridor (West Java)**: Krakatau Steel's EAF upgrades and CCUS pilots, serving domestic markets.
- **Sumatra Resource Zones**: Iron sand mining for alternative feedstocks, coupled with biomass co-firing to cut Scope 1 emissions.

This "archipelagic" strategy mitigates logistics costs (20-30

6 Challenges, Opportunities, and Global Implications

Challenges: High energy costs (coal dependency at 70**Opportunities**: Nickel advantage positions Indonesia as a low-carbon stainless steel exporter; JETP funds $(20B) catalyze pilots, potentially creating 500,000 green jobs by 2040$[10]. $As a CCUS hub, Indonesia offers storage to emission-heavy neighbors (Japan, China). Collaborations via ASEAN forums and like regimes.$

7 Conclusion: From Resource Curse to Green Leadership

Indonesia's steel decarbonization embodies a pragmatic pivot: harnessing nickel and renewables for a low-carbon ascent, distinct from legacy-heavy models in Europe or scale-driven ones in China. The 2025 Roadmap's pillars—EAF/scrap, green H_2, CCUS—provide a feasible path to 50

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