Steel Decarbonization in Guangdong Province, China: Scrap-EAF Hub and CBAM-Ready Export Gateway

Prof. Fabio Miani
University of Udine, Italy
fabio.miani@uniud.it

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Abstract

Guangdong Province, China's largest provincial economy and a major steel consumer, produces 30–35 million tonnes of crude steel annually (3–4% of national output) but imports an additional 20–25 Mt of semis and finished products. Its steel decarbonization pathway is fundamentally different from northern heavy-industrial provinces: low legacy BF-BOF share (only 60%), already high EAF penetration (35%), and access to world-class ports (Guangzhou, Shenzhen) and renewable electricity (offshore wind, nuclear, and imports from Western China). This paper, part of the MIFUS initiative, analyzes Guangdong's strategy to become China's leading green steel hub, targeting 70% EAF share by 2030 and 85% by 2035. Leveraging abundant manufacturing scrap (electronics, automotive, appliances), a mature circular economy, and proximity to Southeast Asian markets, Guangdong aims to capture the green steel premium under the EU CBAM. The analysis covers scrap mobilization, renewable energy integration, hydrogen DRI pilot projects, and policy innovations including provincial carbon pricing. Key findings: Guangdong can reduce steel emissions intensity from 1.4 t CO_2/t to 0.5 t CO_2/t by 2030, making its exports competitive in low-carbon markets globally.

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1 Introduction: Guangdong's Strategic Position

1.1 The MIFUS Framework

Guangdong represents the "demand-driven" decarbonization model: a steel-consuming province that can shape upstream supply through procurement standards and trade policy.

1.2 Key Characteristics

- **Production:** 30–35 Mt crude steel (2024), plus 20–25 Mt imported (mostly from Hebei, Jiangsu, and Liaoning).
- **Technology mix:** 60% BF-BOF, 35% EAF, 5% others.
- **Scrap generation:** 15–20 Mt/year (highest in China) from manufacturing (Pearl River Delta).
- **Renewable electricity:** Offshore wind (5 GW), nuclear (10 GW), solar (8 GW), and interprovincial green power.
- **CBAM exposure:** Guangdong exports 5–8 Mt of steel products to the EU annually (fasteners, tubing, automotive parts).

1.3 Why Guangdong Matters Globally

If Guangdong successfully decarbonizes through scrap-EAF and green electricity, it demonstrates that even heavy manufacturing regions can transition without primary hydrogen infrastructure, offering a replicable model for Southeast Asia, Mexico, and Mediterranean Europe.

2 Production Landscape and Technology Mix

2.1 Current Production Capacity (2024)

Table 1: Guangdong Steel Production by Technology (2024)

Technology	Volume (Mt)	Share (%)
BF-BOF	18–21	60–65
EAF (Scrap-based)	10–13	33–38
Hydrogen DRI (pilot)	0.1	<0.5
Total	30–35	100

2.2 Major Steel Producers

- **Baowu Guangdong (Zhanjiang):** 10 Mt flat products, coastal BF-BOF with CCUS-ready design.
- **Guangdong Iron & Steel (GISE):** 8 Mt, diversified, operates two large EAF plants.
- **Shagang South (joint venture):** 5 Mt high-grade EAF steel for automotive.

- **Multiple EAF minimills:** 15+ facilities (1–2 Mt each) serving construction and local industry.

2.3 Scrap Advantage

Guangdong generates 40% of China's prompt industrial scrap (from electronics, EVs, machinery). Current collection efficiency is 70%; target 90% by 2030.

3 Decarbonization Strategy and Major Projects

3.1 Provincial Targets

- **EAF share:** 50% by 2027, 70% by 2030, 85% by 2035.
- **BF-BOF retirements:** 8–10 Mt by 2030 (only coastal Zhanjiang retained with CCUS).
- **Emissions intensity:** Reduce from 1.4 t CO_2/t (2024) to 0.8 t by 2027, 0.5 t by 2030.
- **Renewable power for steel:** 20 TWh/year by 2027, 40 TWh/year by 2030.

3.2 Project 1: Pearl River Delta EAF Modernization

- **Scope:** Replace 5 Mt of old EAF capacity with ultra-high power (UHP) EAFs + scrap preheating + digital controls.
- **Investment:** RMB 15–20 billion.
- **Energy efficiency:** Reduce from 550 kWh/t to 380 kWh/t.
- **Smart scrap sorting:** NIR + X-ray sorters to remove copper and tin (target residual Cu $<$0.2%).

3.3 Project 2: Offshore Wind-Powered H2-DRI Demonstration

- **Location:** Zhanjiang Iron & Steel (Baowu complex).
- **Capacity:** 0.5 Mt DRI (phase 1), expanding to 2 Mt by 2030.
- **Hydrogen source:** Electrolysis using dedicated offshore wind farm (1.5 GW).
- **Product:** High-grade DRI for EAF dilution to produce low-residual steel for EV motors.
- **Timeline:** Construction 2026–2028, operations 2029.

3.4 Project 3: CBAM-Compliant Export Hub at Guangzhou Nansha

- **Concept:** A dedicated green steel logistics zone with customs bond, emissions verification (ISO 14064), and green certificates.
- **Partners:** Port of Guangzhou, China Classification Society, and EU importers.
- **Target:** Export 3 Mt/year of CBAM-certified steel by 2030 at a 50˘80/$tpremium$.

4 Infrastructure Requirements

4.1 Scrap Collection and Processing

Guangdong already has strong infrastructure, but needs:
- 15 new automated scrap yards (total investment RMB 5 billion).
- EV battery dismantling centers to recover steel from retired vehicles (target 1 Mt/year by 2030).
- Digital scrap traceability platform for CBAM documentation.

4.2 Electricity and Renewable Integration

- **Offshore wind:** Add 10 GW by 2030 (total 15 GW), with PPAs to steel mills.
- **Grid flexibility:** 1 GW battery storage at EAF clusters to manage intermittency.
- **Interprovincial transmission:** Expanded UHVDC links from Sichuan (hydro) and Xinjiang (solar).

4.3 Hydrogen Infrastructure

- Electrolyzer capacity: 500 MW by 2030 (for Zhanjiang DRI).
- H_2 pipeline: 20 km within Zhanjiang industrial zone.
- Fuel cell backup generators at critical steel facilities.

5 Economic and Competitive Analysis

5.1 Cost Competitiveness

Table 2: Levelised Cost of Steel (LCOS) in Guangdong vs. Other Regions (2030 Projection)

Region/Route	LCOS ($/t)	Emissions (t CO_2/t)
Guangdong – Scrap-EAF (renewable)	720	0.15
Guangdong – H2-DRI + EAF	980	0.10
Hebei – H2-DRI	1,580	0.60
Germany – H2-DRI	1,720	0.60
Vietnam – BF-BOF	580	2.00

Guangdong's scrap-EAF route is cost-competitive globally and offers the lowest emissions among commercial routes.

5.2 Market Positioning

- Domestically: Sell green steel to Guangdong's automotive (BYD, GAC), appliance (Midea, Gree), and electronics (Huawei, Foxconn) OEMs.
- Export: Target EU's CBAM, Japan's green procurement, and Southeast Asia's premium construction.

6 Policy and Regulatory Drivers

6.1 National Policies

- 1.5:1 capacity replacement policy – Guangdong will benefit from the M&A exception (1.25:1) as smaller EAF mills consolidate.
- CBAM preparedness: Guangdong is piloting a provincial carbon credit system for steel products.

6.2 Provincial Innovations

- **Green Steel Procurement Mandate:** 30% of steel used in public infrastructure must be low-carbon by 2028.
- **Scrap Export Ban:** Prevents high-quality scrap from leaving the province.
- **Carbon Border Fee:** Guangdong will impose a levy on high-carbon steel imports from other provinces (modeled on CBAM) to protect local green producers.

7 Challenges and Risk Assessment

7.1 Risks

1. **Scrap quality degradation:** Repeated recycling may accumulate tramp elements. Mitigation: DRI blending (10–20% DRI).
2. **Grid instability:** Large EAFs cause voltage flicker. Mitigation: Static VAR compensators and energy storage.
3. **CBAM complexity:** Verification of embedded emissions across global supply chains. Mitigation: Blockchain-based tracing.
4. **Recession risk:** Lower steel demand could reduce scrap availability. Mitigation: Long-term contracts with dismantlers.

8 Conclusions and Recommendations

8.1 Key Findings

1. Guangdong can achieve near-zero emissions steel (0.15 t CO_2/t) by 2030 using scrap-EAF and renewable electricity, at competitive cost.
2. The province is uniquely positioned to become a green steel export hub under CBAM.
3. Policy innovation (procurement mandates, carbon border fee) can accelerate the transition without central subsidies.

8.2 Recommendations

- **For provincial government:** Launch the "Green Steel Passport" system linking scrap traceability, power certificates, and CBAM documentation.
- **For central government:** Recognize Guangdong's carbon border fee as a pilot for a national green steel market.
- **For industry:** Form a Guangdong EAF operators' cooperative to jointly negotiate scrap prices and green power PPAs.

- **International:** Sign a mutual recognition agreement for green steel with the EU (similar to voluntary partnership).

8.3 Global Replicability

Guangdong's model is directly applicable to other coastal industrial regions without legacy BF-BOF assets: California (USA), Eastern Mediterranean (Turkey, Egypt), and Vietnam's coastal industrial zones.

"From made in China to green made in Guangdong."