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Carbon Pricing in the Steel Sector

This report examines how steel producers face carbon pricing in three regions – Europe, East Asia (South Korea and Japan), and emerging markets (India and China) – focusing on production-level emissions (Scope 1 and 2), pricing models (ETS, carbon taxes, CBAM, etc.), industry-specific incentives, use of credits/allowances, regional carbon prices (in local/US$), and any lifecycle-amortization mechanisms. We then propose an algorithm to calculate a **green premium** for low-emission steel that uses these factors, amortizes costs over a project's life (10–20 years), and yields a premium per tonne, per tonne-CO_2 saved, and total lifecycle premium.

Europe

Europe's steel industry operates under the EU Emissions Trading System (EU ETS), which charges for **Scope 1** (on-site fuel/coal) and indirectly for **Scope 2** (purchased electricity) emissions. EU ETS allowance prices have climbed sharply: from about **€30/tCO_2** in early 2021 to above **€80/tCO_2 by 2024** [1], and currently average roughly **€64–65/tCO_2** (about **$70/t$CO_2$**) in 2024 [2]. (For example, a German blast-furnace steel plant emitting ~2.1 tCO_2 per tonne of steel would incur carbon costs of **€130–€170 per tonne** of steel at €65/tCO_2.) The EU still gives trade-exposed steel producers free allowances, but these are being phased down; by 2027 free allocations will largely end [1]. **Carbon Border Adjustment Mechanism (CBAM):** Beginning 2023–2026 (transitional), and fully from 2026, imports of steel (and other carbon-intensive goods) face the EU's CBAM. Importers must surrender **CBAM certificates** equal to embedded CO_2, priced at the EU ETS allowance rate [3]. (Certificates are deducted by any carbon price already paid abroad.) In effect, exporters to the EU must pay roughly the same carbon price as EU producers.

- **Industry-specific measures:** Europe has begun pushing demand for "green steel". For example, German states have proposed rules to **incentivize automakers to buy certified low-CO_2 steel** for cars [4]. Germany has also promoted *Carbon Contracts for Difference* (CCfDs) to underwrite industrial decarbonization: under CCfDs, the government guarantees a floor carbon price for clean steel projects, offsetting their higher costs. Meanwhile, a recent study proposes a **Value-Chain Transition Fund**: a small premium on end-products (e.g. electric vehicles, high-speed trains) would fund steel decarbonization and be recouped in 2–8 years for steel projects [5]. Such mechanisms effectively **amortize** the upfront cost of low-carbon steel over its lifecycle.

- **Carbon credits/allowances:** Under EU ETS, steelmakers use EU allowances. International credits (CERs) are largely phased out. Allowances are 100% freely allocated to eligible steel facilities (subject to benchmarks and free-allocation rules). EU ETS revenues fund R&D and support (Innovation/Modernisation Funds), but there is no formal "amortization" scheme – instead, governments may use revenue to subsidize industry decarbonization.

- **Carbon price:** As of 2024, EU ETS permits trade around **€65/tCO_2 (≈$70/t$CO_2$)** [2]. Future trajectories are much higher (analysts project €100–120 by 2027 [1]). The EU CBAM will effectively impose this price on imports. In sum, the **effective carbon price** faced by EU steel (direct + indirect) is on the order of tens of €/tCO_2 (hundreds of $/t-steel) [1] [3].

- **Lifecycle amortization:** Beyond CCfDs, one proposal suggests recouping steel decarbonization costs by adding a small "carbon premium" into product prices across industries. For example, a study finds that surcharges raising EV prices by ~0.2–1.1% or train production costs by ~0.3–0.6% could finance steel and cement capture technologies, with payback in ~3–8 years [5]. (This aligns with EU discussions on spreading transition costs over supply chains.)

South Korea and Japan

South Korea: South Korea's ETS (K-ETS) has covered major steel producers since 2015. It mandates emission cuts for large emitters (alloys, power, cement, etc.) and covers Scope 1 and indirect Scope 2. In Phase 3 (2021–2025), ~730 entities (including POSCO, Hyundai Steel) participate, covering >70% of national emissions [6]. Each tonne of CO_2 must be covered by one allowance (Korean Allowance Unit, KAU).

- **Current carbon price:** Korea's carbon market has been volatile. Prices have swung from over **KRW 40,000/tCO_2 (~$28)** down to under **KRW 10,000 (~$7)** in 2023 [7]. By October 2025, KAU spot traded near KRW 10,250 (≈$7) [8]. Government forecasts expect prices to rise: projections say **KRW 40,000–61,000** per tCO_2 by 2030 (≈$29–$44) [9].

- **Allowances and credits:** South Korea still allocates large free quotas to EITE sectors (including steel). Under Phase 4 (2026–2030), free allowances to steel will shrink (e.g. free quota cut from 114 to ~89 MtCO_2) [10], forcing integrated mills to buy the rest on the market. The K-ETS allows limited offsets: domestic **Korean Offset Credits (KOC)** and some CDM credits, up to ~5–10% of obligations [11] [12]. (In Phases 1–2 they could use up to 10% offsets; in Phase 3 only 5%.) Offset usage so far has been modest.

- **Industry impacts/incentives:** The steel industry warns that rising carbon costs (combined with US/EU tariffs and cheap imports) threaten profits. For example, POSCO and Hyundai Steel together expect ~KRW 3 trillion ($2.1B) in extra ETS costs over 2026–2030 [13]. At **KRW 30,000/tCO_2** (~$21), their cumulative shortfall is ~20 MtCO_2, roughly 600 billion KRW/year [8]. Industry groups urge relief: proposals include recycling ETS revenues into decarbonization aid (e.g. Germany-style CCfDs) [14]. No dedicated "amortization fund" exists yet, but the government is reforming K-ETS (Phase 4) to improve liquidity and may consider support measures as costs rise. There are few targeted incentives (most government focus is R&D in hydrogen steel), though power sector free allocations will be reduced (50% auction by 2030), which may indirectly raise steel power prices.

Japan: Japan currently has **no economy-wide carbon price for steel**, but policy is evolving. Japan maintains a small national carbon tax (introduced 2012) of **¥289/tCO_2 (~$2)** [15] – effectively negligible for steel. However, under the *Green Transformation (GX) Initiative*, Japan launched a voluntary corporate ETS (GX-ETS) in 2023, to become mandatory by 2026 [16]. Initially, ~300–400 large firms (emitting >100kt CO_2) will set targets and trade allowances (mostly free-allocated) [17]. Allowances will have government-set floors and ceilings; companies may also use **J-Credits** (existing voluntary credits) to meet obligations [15]. The GX-ETS rules (once finalized) may extend to heavy industry, including steel.

- **Scope 1/2 and pricing:** Today Japanese steelmakers pay the €2 equivalent tax on fuel (scope 1) and no price on electricity (scope 2 aside from power prices). The new GX-ETS and a planned fossil fuel levy (2028) will add explicit carbon costs. Absent these, Japan's steel sector currently faces an

effective carbon price near zero domestically, though government plans strongly encourage zero-emission steel.

- **Credits/allowances:** Japan's emerging carbon market includes **J-Credits**, a voluntary registry of emissions reductions. As of early 2024, a new Tokyo Carbon Credit Market platform trades J-Credits and voluntary credits [18]. In the near future, GX-ETS companies can use credits (likely limited % of their cap) to comply.

- **Industry incentives:** Japan is actively supporting green steel demand. The government's **"Green Steel for GX"** strategy defines low-carbon steel and offers procurement and subsidies. Notably, the Green Purchasing Act was amended (2025) to prioritize such steel, and the *Clean Energy Vehicle subsidy* was increased by up to **¥50,000 (≈$350)** per vehicle if it uses steel from innovative electric-arc furnaces [19]. In short, automakers get higher EV subsidies when buying "green" steel. Steel producers also have brands (NS Carbolex®, JFE JGreeneX®, etc.) under a JISF mass-balance certification, with government support. These policies spread the cost of steel decarbonization onto auto and other demand sectors (an amortization in industry), rather than burden steel costs fully at once.

- **Carbon price:** Summarizing, Japan's current carbon price is **very low** (¥289/t ≈ $2 [15]). The forthcoming GX-ETS is expected to introduce a price signal (with floors/ceilings set by government), but initial prices will likely remain modest compared to EU or Korea.

Emerging Economies (India and China)

India: India has no operational carbon tax or ETS for steel. A legacy *coal cess* (a coal usage tax) once added ~₹400/ton of coal (~$5.7/t$CO_2$) [20], but this flat "carbon levy" was abolished in 2025 [20]. As of late 2025, **no national carbon price** applies to steel. The government is developing a **Carbon Credit Trading Scheme (CCTS)** (adopted July 2024) – an intensity-based ETS covering 9 industrial sectors (likely including steel) [21] – but it is still in regulatory design and initial rollout. Until then, Indian steelmakers (which produce ~3.6 tCO_2/ton crude via BF-BOF) face essentially **zero domestic carbon cost** [22].

- **Export pressures:** However, EU CBAM (effective 2026) will levy a carbon tax on Indian steel exports to Europe [23]. This external "carbon border tax" effectively forces Indian mills to decarbonize if they want EU markets. (Industry is uncertain how CBAM rates will be calculated [24], but all blast-furnace steel – ~60% of Indian exports – will incur significant CBAM charges.) For example, analysts expect EU CBAM to raise India's steel export costs substantially, prompting some mills to seek new markets [25] [26].

- **Pricing models:** Absent domestic ETS, India has relied on performance standards (the existing PAT scheme) and will use CCTS intensity targets. The Press Information Bureau notes India is "moving towards" a rate-based ETS (CCTS) covering heavy industries [21], and has approved voluntary carbon credit methodologies (renewables, efficiency, etc.) [27]. The CCTS will issue credits for beating intensity benchmarks, and firms can use credits to comply, but it is not yet a strict cap.

- **Use of credits/allowances:** India is establishing a voluntary carbon market (domestic credits, ~8 methodologies approved) [27]. When CCTS becomes operational, facilities outperforming their targets will earn certificates. These credits may be sold or used against future obligations. There is no international linkage.

- **Price per tCO_2:** Since India has no effective carbon pricing on steel, the **implied carbon price is essentially zero domestically** [28]. (By contrast, the coal cess before abolition was about \$5–6/tCO_2 [20].) CCTS may yield an implicit price signal in future, but nothing concrete today.

China: China's national ETS (launched 2021) currently covers power generation and, since 2024, has been phasing in industry. As of 2025, around 3,500 installations are in the system (power, cement, steel, aluminum) [29]. All allowances are initially **freely allocated** (output-based benchmarks); Chinese companies surrender allowances to cover annual scope 1 emissions. China's ETS price has historically been **low**: secondary market trading averaged about **CNY 96/tCO_2 (~USD 13/t)** as of mid-2024 [30], roughly one-seventh of EU levels.

- **Sector coverage:** Although the ETS framework now includes steel and cement, Phase 1 (2024–26) is largely a "familiarization" period where covered firms monitor and report emissions without strict caps [31]. Full compliance (requiring allowance surrender for steel) is planned from 2027 onwards [31]. Today, Chinese steel producers face **no direct carbon charge**: they remain effectively unconstrained, similar to India [28] [32].

- **Carbon price:** The current benchmark is the ETS allowance price. As noted, China's national allowance price is around **¥96** (RMB) per tCO_2 [30] (≈**\$13**). Regional pilot markets had traded even lower (often \$5–\$10). For context, China's power ETS price (~¥80–90 by 2023) was only ~€10/t [32]. Analysts expect these prices to slowly rise as China tightens caps, but no dramatic carbon cost burdens exist yet.

- **Offsets:** China relaunched its domestic offset program in 2024 (CCER – China Certified Emissions Reductions) [33]. This voluntary credit market will eventually allow projects (e.g. renewable energy, industry efficiency) to generate tradable credits. It is unclear if or how CCER credits will be used in the mandatory ETS (likely limited by future rules).

- **Industry incentives:** China's government is heavily investing in green steel (hydrogen DRI, CCUS pilots) even without carbon pricing. A January 2025 EU–China agreement calls for "green-steel certificates" to boost low-carbon supply chains (pilot scheme led by Baowu and EU firms) [34]. However, formal incentives for end-users (auto, construction) are still nascent. Unlike Japan, China has no known car-sector subsidy tied to green steel. Instead, China's strategy is supply-focused – supporting steelmakers and technology.

- **Price per tCO_2:** In summary, China's **carbon price** (ETS allowance price) is roughly **¥80–100/t** (≈\$11–\$14) [30] [32]. But as steel is just entering compliance, the **effective steel carbon cost today is essentially zero**, pending future market tightening.

Regional Comparison of Carbon Prices

- **Europe (EU ETS/CBAM):** ~€60–80 per tCO_2 (~\$65–\$85) and rising [2] [1].

- **South Korea (K-ETS):** ~₩10,000 per tCO_2 (≈$7) in 2025 [8] [7]; projected to reach ₩40,000–61,000 ($29–$44) by 2030 [9].
- **Japan:** ~¥289 per tCO_2 (≈$2) via carbon tax [15]; voluntary GX-ETS not yet price-competitive.
- **India:** effectively $0 (no price); a coal cess of ~$5/t was removed [20].
- **China:** ~¥96 per tCO_2 (~$13) in 2024 [30] (power sector ETS); steel soon to be priced.

(Currency conversion: €1≈$1.1, ₩10,000≈$7, ¥100≈$0.68, ₹87≈$1.)

Proposed Algorithm for a Low-Carbon Steel Green Premium

To price a **green premium** for low-emission steel (relative to conventional steel), we incorporate region-specific carbon costs, project life, industry factors, and CBAM/credit values. A generalized algorithm might proceed as follows:

1. **Inputs:**
2. **Regional carbon price** P_{region} (in $/$tCO_2$). Use local carbon price (ETS or tax) for the region where steel is produced or consumed.
3. **Emissions reduction** ΔE (tCO_2 saved per tonne of steel) = (emissions of conventional steel – emissions of low-carbon steel) per tonne.
4. **Project lifetime** L (years) and **annual production** Y (tonnes/year).
5. **Industry factor** f_{ind} (dimensionless) >1 to reflect higher willingness-to-pay or regulatory pressure in certain sectors (e.g. automotive vs. construction).
6. **CBAM/exports:** if steel will be sold under EU CBAM, include an **EU CBAM price** P_{CBAM} (≈EU ETS price) to capture avoided border tax.

7. **Carbon credit value** P_{credit} ($/$tCO_2$): potential revenue per tCO_2 from selling credits or subsidies (e.g. CDM/J-Credit value).

8. **Compute carbon-cost basis:**

$$\text{Base premium per tCO}_2 = (P_{\text{region}} + P_{\text{CBAM}}) \times f_{\text{ind}} \;-\; P_{\text{credit}}.$$

   This is the effective carbon-price differential per tonne CO_2, adjusted for industry weighting and minus any credit revenues.

9. **Premium per tonne steel:**

$$\text{Premium}_{\text{per tonne}} = \Delta E \;\times\; \big[(P_{\text{region}} + P_{\text{CBAM}}) \times f_{\text{ind}} - P_{\text{credit}}\big].$$

   In words, multiply the emissions saved per tonne by the net carbon price. This yields an added cost ($/tonne-steel) for using low-carbon instead of conventional steel.

10. **Premium per tCO_2:**
   Optionally report the **premium per tCO_2 saved** as

$$\text{Premium}_{\text{per tCO}_2} = (P_{\text{region}} + P_{\text{CBAM}}) \times f_{\text{ind}} \; - \; P_{\text{credit}},$$

which shows the effective price signal per tonne of CO_2 abated.

11. **Lifecycle (project) premium:**
Over a project producing Y tonnes/year for L years, total low-carbon steel output is $Y \times L$. Thus

$$\text{Total lifecycle premium} = \text{Premium}_{\text{per tonne}} \; \times \; Y \; \times \; L.$$

This is the aggregate additional cost (or price premium) over the project's life.

12. **Amortization:**
One can convert to an annualized premium by dividing by L, or by applying a discount rate for NPV calculations. In simple terms, the extra cost per tonne per year is

$$\text{Annualized premium per tonne} = \frac{\text{Premium}_{\text{per tonne}}}{L}.$$

This spreads the upfront decarbonization premium evenly over the project life (as done in transition-fund or CCfD schemes [5] [14]).

Note: All currency units should be consistent (e.g. convert local prices to USD). The algorithm allows for different scenarios by adjusting P_{region} for each country/market (e.g. €70/t in EU vs. $7/t in Korea), setting f_{ind} (e.g. 1.2 for auto sector), and including CBAM values (≈EU ETS price) if relevant. For example, exporting low-carbon steel to Europe could add $P_{\text{CBAM}} \approx €70$ per tCO_2 avoided (since CBAM avoids paying EU price on imports).

This structured approach ensures the premium reflects **regional carbon costs**, **emission savings**, **industry differences**, and **market mechanisms** (CBAM, credits). The outputs – premium per tonne, per tCO_2, and total lifecycle premium – give clear pricing signals for manufacturers and buyers. Such a formula can be refined with real data: e.g. EU: $P_{\text{region}} \sim \$70/t$; Korea: $\sim \$7/t$ (rising to \$30–\$40 by 2030) [8] [9] ; Japan: $\sim \$2/t$ (today) [15] ; India: ~\$0 (with CBAM impact if exporting) [20] [23] ; China: $\sim \$13/t$ [30] . These feed into the algorithm above to yield practical green premiums.

Sources: Official and industry analyses provide the above data and models. For Europe, EU legislative texts and market reports give ETS prices and CBAM rules [3] [2] [1] . South Korea and Japan information comes from government and market updates (e.g. Korean ETS auction plans, Japan GX reports) [8] [7] [15] [19] . India's carbon pricing is described by government releases and news reports [35] [20] . China's ETS data are from ICAP and climate news [30] [32] . Proposed financial frameworks (CCfDs, transition funds) are documented in academic and industry sources [5] [14] . These ensure our analysis and the green premium algorithm are based on the latest policy contexts and price levels.

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[1] [22] [28] [32] Two Worlds | Carbon Pricing Splits the Steel Industry
https://www.steelonthenet.com/insights/steel-carbon-divide.html

[2] EU Emissions Trading System (EU ETS) | International Carbon Action Partnership
https://icapcarbonaction.com/en/ets/eu-emissions-trading-system-eu-ets

[3] Carbon Border Adjustment Mechanism - Taxation and Customs Union
https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

[4] Germany calls on the EU to promote the use of green steel in the automotive industry
https://gmk.center/en/news/germany-calls-on-the-eu-to-promote-the-use-of-green-steel-in-the-automotive-industry/

[5] Financing high-cost measures for deep emission cuts in the basic materials industry – Proposal for a value chain transition fund - ScienceDirect
https://www.sciencedirect.com/science/article/pii/S0301421524004336

[6] [7] [16] [17] Asia's carbon pricing shift: How Japan, Korea, Indonesia step up ETS reforms | NEWS | Reccessary
http://www.reccessary.com/en/news/asia-carbon-pricing-shift-japan-korea-indonesia-ets-reform

[8] [9] [10] [13] [14] Korean steel industry hit by carbon permit costs, high tariffs, ETInfra
https://infra.economictimes.indiatimes.com/news/construction/korean-steel-industry-hit-by-carbon-permit-costs-high-tariffs/124632233

[11] [12] Korea Emissions Trading System (K-ETS) | International Carbon Action Partnership
https://icapcarbonaction.com/en/ets/korea-emissions-trading-system-k-ets

[15] [18] Inside Japan's GX-ETS carbon market and its global climate impact | Carbon Direct
https://www.carbon-direct.com/insights/inside-japan-s-gx-ets-carbon-market-and-its-global-climate-impact

[19] Decarbonizing Steel (Part 1: Japan): Remaining Challenges for Mass Balance Products | Column | Renewable Energy Institute
https://www.renewable-ei.org/en/activities/column/REupdate/20251023.php

[20] Indian coal prices to be lower after tax revision, industry officials say | Reuters
https://www.reuters.com/sustainability/boards-policy-regulation/indian-coal-prices-be-lower-after-tax-revision-industry-officials-say-2025-09-04/

[21] [27] [35] Press Note Details: Press Information Bureau
https://www.pib.gov.in/PressNoteDetails.aspx?id=154721&NoteId=154721&ModuleId=3®=3&lang=2

[23] [24] [25] [26] India's steel exports to Europe set to drop as EU carbon tax looms | Reuters
https://www.reuters.com/sustainability/boards-policy-regulation/indias-steel-exports-europe-set-drop-eu-carbon-tax-looms-2025-12-05/

[29] [30] [31] [33] China National ETS | International Carbon Action Partnership
https://icapcarbonaction.com/en/ets/china-national-ets

[34] Targeted Incentives Key to Accelerating China's Steel Sector...
https://www.climatebonds.net/news-events/press-room/press-releases/targeted-incentives-key-accelerating-chinas-steel-sector-transition