

Critical Raw Materials Security | Steel Supply Chain Vulnerabilities



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Steel's Vulnerability to Supply Chain Weaponisation

Executive Summary

The global steel industry faces unprecedented vulnerability to supply chain disruption through the weaponisation of **critical raw materials**. Beyond traditional concerns about iron ore and metallurgical coal, the industry's transition toward advanced steelmaking technologies has created new dependencies on materials concentrated in geopolitically sensitive regions. This analysis examines the strategic implications of these vulnerabilities and proposes mitigation strategies for steel producers navigating an increasingly fragmented global trade environment.

Geographic Concentration and Emerging Dependencies

The steel industry's raw material security challenges have fundamentally shifted over the past decade. While iron ore and **metallurgical coal** remain the backbone of traditional steelmaking, the industry's decarbonisation journey has introduced critical dependencies on specialised materials essential for advanced technologies. These include chromium, molybdenum, and niobium for hydrogen-resistant infrastructure, advanced refractories for extreme temperature operations, and **graphite electrodes** for electric arc furnace steelmaking.

The concentration of these materials in a handful of countries creates systemic risks that extend far beyond traditional market volatility. Unlike historical commodity cycles driven by supply-demand imbalances, today's raw material security concerns centre on deliberate **supply chain weaponisation** as a tool of geopolitical leverage.

Metallurgical Coal: The Australia Dependency

Australia's dominance in metallurgical coal supply represents perhaps the most immediate vulnerability for global steel producers. The country supplies approximately **54% of global seaborne coking** with the vast majority coming from Queensland's Bowen Basin. This concentration was starkly illustrated



during Australia's trade tensions with China from 2020-2022, when Chinese import restrictions on Australian coal created severe supply disruptions and price volatility.

Modern blast furnace operations require specific coal qualities that cannot be easily substituted. Premium low-volatile hard coking coal, essential for high-quality steel production, is predominantly sourced from just three Australian mines: Peak Downs, Saraji, and Goonyella Riverside. Any disruption to these facilities could severely impact global steel production capacity.

Iron Ore and Critical Materials Concentration

While iron ore appears more geographically diversified than metallurgical coal, effective control remains concentrated among three mining giants: Vale, Rio Tinto, and BHP Billiton. These companies control approximately **70% of global seaborne iron ore trade**, creating oligopolistic pricing power that extends beyond pure market forces.

High-grade ores above 65% iron content are essential not only for efficient blast furnace operations and emission reduction but also for **direct reduced iron (DRI) production**. DRI processes require consistent, high-quality ore to achieve the metallisation rates necessary for economic operation. Sweden's LKAB provides some diversification with its high-grade magnetite pellets, but volumes remain limited compared to Australian and Brazilian sources.

The refractory materials essential for steelmaking furnaces face significant concentration risks often overlooked by industry executives. Magnesite, critical for basic oxygen furnace linings, is dominated by Chinese production controlling approximately 70% of global supply. Graphite electrodes for electric arc furnaces present another vulnerability, with natural graphite predominantly sourced from China (65% of global production), while the specialised needle coke required for ultra-high-power electrodes depends on petroleum refining byproducts concentrated in specific refineries.

Critical **ferroalloys** face extreme geographic concentration that poses systemic risks to steel quality and functionality. South Africa dominates ferrochrome production with 75% of global supply, while China controls 60% of ferrosilicon output. The transition toward hydrogen-based steelmaking introduces entirely new dependencies on materials like niobium (90% from Brazil) and zirconium for advanced refractories, creating potential bottlenecks that could constrain the entire industry's decarbonisation timeline.

Hydrogen infrastructure presents particularly acute vulnerabilities through **hydrogen embrittlement**—a phenomenon where hydrogen atoms diffuse into steel structures, causing catastrophic brittleness and failure. Preventing this requires specialised steel grades containing specific **rare earth elements** including yttrium and cerium for grain boundary strengthening, and scandium for improved hydrogen resistance¹. China dominates global supply of these critical rare earths: yttrium (95% of global production), cerium (85%), and scandium (66%). Any disruption to these supplies could compromise the structural integrity of hydrogen storage tanks, pipelines, and processing equipment essential for green steel production, potentially forcing delays in decarbonisation projects or creating safety risks in hydrogen operations.



Supply Chain Weaponisation and Strategic Response

China's use of rare earth export restrictions from 2010-2012 provides a blueprint for how critical materials can be weaponised for geopolitical advantage. During territorial disputes with Japan, China effectively embargoed rare earth exports, causing prices to spike over 1,000%. Similar scenarios could unfold across multiple material categories, with China's dominance in magnesium production, graphite supply, and ferroalloy processing creating multiple pressure points where export restrictions could severely impact steel production costs.

Governments worldwide are increasingly viewing critical materials as strategic assets. Indonesia's nickel export ban demonstrates how resource nationalism can rapidly reshape global supply chains, while Chile's proposed lithium nationalisation illustrates how political changes can threaten long-term supply security.

Strategic Mitigation Approaches

Effective raw material security requires diversification strategies that extend beyond simple geographic distribution. Steel producers must evaluate supply chains based on political stability, regulatory predictability, and alliance relationships. Sourcing from politically aligned countries may command price premiums but provides strategic insurance against supply weaponisation.

Steel producers must develop **strategic stockpiling programmes** that maintain buffer inventories of materials vulnerable to supply disruption. Several government programmes² provide templates for public-private cooperation, often offering opportunities for long-term supply contracts that reduce market volatility while supporting national security objectives.

Technology hedging strategies enable steel producers to maintain flexibility by supporting multiple production routes. Installing both hydrogen-based Direct Reduced Iron (H₂-DRI) and Electric Arc Furnace capabilities provides optionality to switch between iron ore and scrap steel feedstocks based on availability and pricing. Similarly, energy input diversification through hybrid systems that can operate on hydrogen with natural gas backup reduces dependency on single fuel sources. Some producers are exploring biomass gasification as an alternative reducing agent, while others invest in modular technologies that can process various raw material grades. These technological approaches reduce vulnerability to single-source supply disruptions while maintaining operational flexibility.

Regional cooperation frameworks, such as the G7's Partnership for Global Infrastructure³, offer opportunities to develop more secure supply networks that reduce dependency on single-source suppliers.

Building Strategic Resilience

The steel industry's raw material security challenges extend far beyond traditional supply-demand dynamics into geopolitical strategy and supply chain weaponisation. The industry's transformation toward advanced technologies has created new vulnerabilities requiring fundamental changes in procurement strategies, inventory management, and investment planning.



Modern raw material security requires sophisticated intelligence capabilities that monitor geopolitical developments and supply chain vulnerabilities, while long-term security may require investment in alternative material development and advanced recycling technologies. Effective coordination requires trade policies that prevent adversarial suppliers from exploiting dependencies, with steel producers supporting government initiatives that promote supply chain diversification.

Steel producers that proactively address these vulnerabilities through diversified supply networks, strategic stockpiling, and technology hedging will be better positioned to navigate an increasingly uncertain geopolitical environment. Success requires steel executives to think strategically about **raw material security** as a core business competency, not merely a procurement function.

The companies that master this challenge will gain competitive advantages that extend far beyond simple cost optimisation to encompass strategic resilience in an uncertain world.

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Sources and Notes:

¹ Kim, S.J., Ryu, K.M. & Oh, Ms. (2017). Addition of cerium and yttrium to ferritic steel weld metal to improve hydrogen trapping efficiency. *International Journal of Minerals, Metallurgy and Materials*, Vol. 24, pp. 415""422.

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² Government stockpiling programmes include the US Strategic National Defense Stockpile, Japan's Strategic Materials Stockpile, South Korea's National Strategic Materials Reserve, and Germany's Federal Reserve of Strategic Raw Materials.

³ The G7 Partnership for Global Infrastructure (PGII) is a values-driven initiative launched in 2022 to mobilise \$600 billion in infrastructure investment, including critical minerals supply chains, as an alternative to China's Belt and Road Initiative.

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