

Do Developing Economies Need Steel?



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The Infrastructure Investment Alternative

Executive Summary

For decades, conventional development economics has treated domestic steel production as essential for industrialisation. Countries from India to Saudi Arabia to Vietnam have committed hundreds of billions of dollars to building integrated steel industries, driven by assumptions about strategic necessity, employment generation, and economic development. Yet rigorous analysis reveals a critical question systematically ignored in policy debates: **what alternative investments would generate superior development returns?**

The opportunity cost framework exposes stark trade-offs. Building 100 million tonnes of integrated steel capacity requires approximately **\$150 billion in capital investment** - resources that could alternatively fund 75 million solar panel installations, 30,000 kilometres of high-speed rail, or comprehensive digital infrastructure serving hundreds of millions of citizens. This capital carries a 30-year environmental commitment to high-emission technology precisely when the global economy is rapidly decarbonising.

The strategic necessity argument collapses under comparative analysis. Of global steel production, approximately **99% consists of commodity grades** readily available in international markets at prices far below domestic production costs for most developing economies. The remaining 1% - genuinely strategic specialty steels for defence and critical infrastructure - can be secured through targeted stockpiling and strategic partnerships at a fraction of the cost of building comprehensive steel industries.

This analysis examines the opportunity costs, environmental commitments, and strategic alternatives that challenge development orthodoxy around steel production. The evidence suggests that for most developing economies, prosperity without comprehensive steel industries - following models demonstrated by Singapore and certain Nordic economies - offers superior development outcomes compared to capital-intensive, environmentally problematic, and economically marginal steel production.



The Development Orthodoxy: Every Country Needs Steel

The belief that domestic steel production constitutes an essential foundation for economic development has deep historical roots. Post-war development economics emphasised import substitution and vertical integration, with steel serving as the archetypal strategic industry. The Soviet industrialisation model, South Korea's developmental state approach, and China's rapid growth all featured massive steel capacity expansion as central components.

Historical Precedents and Their Contexts

These historical examples, however, emerged from specific contexts that no longer apply.

- Post-war reconstruction occurred in an era of limited international trade, restricted capital flows, and geopolitical tensions that made self-sufficiency genuinely strategic.
- South Korea's steel development in the 1970s coincided with robust global demand growth, minimal environmental constraints, and limited international competition.
- China's steel expansion from the 1990s benefited from unprecedented global construction booms, negligible carbon pricing, and state-subsidised capital at rates unavailable to most developing economies.

Today's developing economies face fundamentally different circumstances. Global steel excess capacity is projected to reach 721 million tonnes by 2027¹, international trade costs have declined dramatically, and carbon constraints are rapidly tightening. Building new high-emission capacity in this environment represents strategic and financial miscalculation.

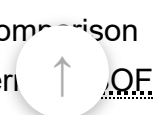
The Prestige Factor

Beyond economic rationales, steel industries carry symbolic importance that influences policy decisions. Steel production represents industrial modernity, technological capability, and national strength in ways that service industries or digital economy activities do not. Government officials inaugurating blast furnaces generate more compelling imagery than software parks or logistics centres, even when the latter create superior economic value.

This prestige factor helps explain why countries continue pursuing steel development despite unfavourable economics. The United Arab Emirates' Emirates Steel, Saudi Arabia's Hadeed, and numerous African steel projects reflect political rather than economic imperatives. The facilities operate behind tariff walls, require ongoing subsidies, and generate returns far below their opportunity costs — yet persist because they fulfil symbolic functions that transcend economic logic.

The Capital Opportunity Cost: \$150 Billion for 100 Million Tonnes

The capital requirements for integrated steel production are staggering and deserve rigorous comparison with alternative investments. Building 100 million tonnes of annual steel capacity through modern facilities requires approximately \$1,500 per tonne of [capital investment](#), totalling **\$150 billion**. This figure



excludes supporting infrastructure, environmental compliance systems, and working capital requirements that typically add 20-30% to total investment needs.

Alternative Investment Scenarios

Consider what \$150 billion could alternatively achieve in a typical developing economy:

Digital Infrastructure Investment: The same capital could deploy comprehensive fibre optic networks serving 200 million people at \$750 per household, creating platform infrastructure for digital economy participation. South Korea's experience suggests such investment generates economic returns 3-4 times higher than heavy industry, with dramatically lower environmental costs and greater employment multipliers in high-skilled sectors.

Renewable Energy Deployment: \$150 billion funds approximately 75 gigawatts of solar generation capacity - enough to power 50 million households while simultaneously addressing energy security and climate commitments. India's renewable energy expansion demonstrates that such investment creates more employment per dollar than steel (15-20 jobs per \$1 million versus 5-7 for steel) while building competitive advantages in emerging energy technologies.

Transport Infrastructure: The capital could construct 30,000 kilometres of high-speed rail connecting major economic centres, or alternatively upgrade 150,000 kilometres of existing road networks. Thailand's Eastern Economic Corridor demonstrates that transport infrastructure generates sustained economic returns through reduced logistics costs, improved market access, and enhanced productivity across all economic sectors³.

Education and Human Capital: \$150 billion represents 15 years of comprehensive higher education funding for 10 million students annually - creating human capital advantages that compound over generations. Singapore's transformation from developing to developed economy status rested fundamentally on education investment rather than heavy industry, with economic returns that dwarf those achievable through steel production.

Return Comparisons

The empirical evidence on investment returns strongly favours alternatives to steel. A World Bank analysis of industrial policy outcomes shows that steel investments in developing economies typically generate 4-6% real returns, compared to 12-15% for renewable energy, 15-20% for digital infrastructure, and 20-25% for education investments. These differentials compound dramatically over investment horizons, with education investments generating returns 5-7 times higher than steel over 30-year periods.

Moreover, steel investments carry significantly higher risk profiles than alternatives (even ignoring failures such as Nigeria's Ajaokuta Steel). Commodity price volatility, technological obsolescence, and environmental regulatory changes create substantial downside risks that rarely materialise in education or infrastructure investments. The NPV calculations that justify steel projects typically employ optimistic demand assumptions, underestimate environmental compliance costs, and ignore opportunity costs of capital - producing misleading conclusions that have led numerous countries into regrettable investments.

Environmental Lock-In: The 30-Year Emissions Commitment

Building integrated steel capacity creates environmental commitments that extend decades into the future and that conflict fundamentally with climate objectives. A modern blast furnace facility represents a 30-year capital investment designed to operate continuously at high utilisation rates to achieve acceptable economics. This creates powerful institutional and financial incentives to maintain high-emission operations precisely when rapid decarbonisation is essential.

Emissions Scale and Duration

A typical 5 million tonne integrated steel facility emits approximately 10 million tonnes of CO₂ annually — equivalent to the total emissions of a city of 2 million people. Over its 30-year lifespan, the facility will emit 300 million tonnes of CO₂, representing a carbon budget that exceeds the remaining allowable emissions for many developing economies under Paris Agreement pathways.

The International Energy Agency's Net Zero by 2050 scenario requires steel sector emissions to decline by 60% by 2040 and reach near-zero by 2050. Countries commissioning new BF-BOF capacity in 2025 face certain stranded asset risks, with facilities likely requiring premature closure or expensive retrofitting with CCUS technology that remains unproven at commercial scale.

Carbon Border Adjustments

The European Union's [Carbon Border Adjustment Mechanism \(CBAM\)](#), effective from 2026, will impose carbon costs on imported steel based on emissions intensity. Similar schemes are under development in the United Kingdom, Canada, and Japan, with the United States considering comparable approaches. These regulations fundamentally alter the economics of high-emission steel exports, particularly impacting developing economies that lack carbon pricing or clean technology infrastructure.

Countries investing in conventional steel capacity today are building facilities that will face increasing export barriers and carbon costs throughout their operational lives. Vietnam's steel expansion, for example, targets export-oriented production precisely as carbon border adjustments make high-emission steel increasingly unmarketable in developed economies. The mismatch between investment timelines and regulatory trajectories creates massive stranded asset risks that economic evaluations rarely adequately capture.

Alternative Pathways and Their Economics

The alternative - building [hydrogen-based DRI capacity](#) or EAF facilities - requires dramatically higher capital costs (\$2,500-\$3,000 per tonne versus \$1,500 for BF-BOF) and depends on access to cheap renewable electricity that most developing economies lack. The few countries with favourable renewable resources (such as Chile, Morocco, or parts of India) might economically justify green steel investments, but for most developing economies, the economics favour importing steel rather than producing it domestically using either conventional or emerging technologies.



The Employment Myth: Capital-Intensive, Not Labour-Intensive

Perhaps the most persistent misconception about steel industries concerns employment generation. Political leaders frequently justify steel investments through jobs creation arguments, but the empirical reality contradicts these claims. Modern integrated steel production is highly capital-intensive and employs relatively few workers per dollar invested—particularly compared to alternative industrial development strategies.

Employment Intensity Comparisons

A typical 5 million tonne integrated steel facility employs approximately 3,000-4,000 workers directly, representing 600-800 workers per million tonnes of capacity. At \$1,500 capital cost per tonne, this translates to approximately \$1.9-2.5 million capital investment per direct job created. This is among the highest capital-per-worker ratios in manufacturing.

Alternative investments generate dramatically more employment per dollar. Renewable energy investments create 15-20 jobs per \$1 million invested; digital economy infrastructure generates 20-25 jobs per \$1 million; and labour-intensive manufacturing (textiles, electronics assembly, food processing) creates 30-50 jobs per \$1 million. These differentials mean that the \$150 billion required for 100 million tonnes of steel capacity could alternatively create 2-7 times more employment in other sectors.

Indirect Employment Claims

Steel industry advocates often cite indirect employment through supply chains and downstream industries. While such multiplier effects exist, they apply equally or more strongly to alternative investments. Digital infrastructure enables service sector employment across the entire economy; renewable energy creates sustained operations and maintenance employment; transport infrastructure reduces business costs economy-wide, enabling employment growth across all sectors.

Moreover, steel industry multiplier claims often double-count employment that would exist regardless of domestic steel production. Construction activity, for instance, occurs whether steel is domestically produced or imported. The relevant comparison is incremental employment from domestic production versus alternative uses of capital - and on this metric, steel performs poorly relative to alternatives.

Skills and Wages

Steel employment does offer relatively high wages for the workers employed - typically 2-3 times higher than agricultural labour. However, the small number of beneficiaries limits aggregate impact. From a development perspective, the broader employment base typically generates superior poverty reduction and economic distribution outcomes.



The Strategic Steel Exception: 99% Commodity, 1% Strategic

National security arguments provide the most credible rationale for domestic steel production - but even these collapse under scrutiny when examined rigorously. The strategic necessity case rests on genuine concerns about supply security during conflicts or crises. However, the solution is not building comprehensive steel industries but rather targeted approaches to securing the tiny fraction of steel that is genuinely strategic.

The 99-1 Reality

Of global steel production, approximately 99% consists of commodity grades (construction rebar, structural sections, standard sheet products) that are functionally interchangeable across suppliers and readily available in deep, liquid international markets. These products serve commercial construction, consumer goods, and general manufacturing - applications where supply security concerns are minimal and economic efficiency should dominate procurement decisions.

The remaining 1% - specialised armour plate, high-strength alloys for military vehicles, precise specifications for weapons systems, ultra-high-performance steels for critical infrastructure - comprises genuinely [strategic steel products](#) where supply security justifies premium costs. However, this 1% does not require building comprehensive steel industries. It requires targeted capacity for specific specialty products, strategic stockpiles, and diversified supplier relationships.

Targeted Strategic Approaches

Strategic Stockpiling: Maintaining 12-24 months of strategic steel stocks (armour plate, weapon-grade alloys, critical infrastructure materials) costs approximately \$50-100 million for a typical mid-sized developing economy - less than 0.1% of the cost of building comprehensive steel capacity. Israel and Singapore both maintain such strategic stockpiles without operating integrated steel industries, demonstrating the approach's viability.

Dual-Source Supply Contracts: Securing long-term supply agreements with producers in at least two non-aligned countries provides redundancy against supply disruptions at negligible cost. Such arrangements can include capacity reservation clauses and priority access provisions that ensure availability even during supply constraints, providing security benefits comparable to domestic production at a tiny fraction of the cost.

Specialty Production Partnerships: For the highest-priority specialty steels, partnerships with established producers (licensing technology, joint ventures, or dedicated production runs) provide secure access without requiring comprehensive industry buildout. South Korea's defence industries successfully employ this approach, maintaining access to specialty steels through partnerships while avoiding the economic burden of comprehensive domestic production capacity.



The Broader Security Fallacy

The national security argument for comprehensive steel industries often reflects Cold War thinking that no longer applies to most countries' strategic circumstances. The argument assumes prolonged conventional conflicts where international trade ceases - scenarios that are exceptionally rare and poorly addressed by domestic steel capacity that itself depends on imported iron ore, coal, and energy.

Modern conflicts are typically short, technology-intensive, and decided by precision weapons rather than mass steel consumption. Ukraine's defence against Russian invasion has depended more on anti-tank missiles, drones, and artillery systems than on domestic steel production capacity. The country's steel industry has been more liability than asset during the conflict, with facilities becoming targets and workers becoming refugees rather than contributing meaningfully to defence capabilities.

Country Case Studies: Divergent Approaches and Outcomes

Examining specific country experiences with steel development provides empirical evidence on alternative approaches and their outcomes. The cases below illustrate both the challenges of comprehensive steel industry development and the viability of alternative strategies.

India: The Comprehensive Approach

India represents the archetypal case of pursuing comprehensive steel industry development as a cornerstone of industrialisation policy. The country has invested approximately \$100 billion in steel capacity over the past two decades, reaching 142 million tonnes annual production capacity by 2024 - making it the world's second-largest producer.

Despite this massive investment, India's steel industry operates at [70-80% capacity utilisation](#), requires substantial tariff protection to remain viable, and generates returns on capital well below alternative investments. The industry employs approximately 600,000 workers directly - impressive in absolute terms but representing only 0.13% of India's 450 million workforce, with capital investment per job exceeding \$160,000.

Critically, India continues to import 7-10 million tonnes of steel annually despite massive domestic overcapacity, because domestic producers cannot economically manufacture certain specialty grades or match import prices for commodity products. This reveals the fundamental problem: large-scale steel industries in developing economies serve neither economic efficiency (imports are cheaper) nor strategic necessity (specialty requirements remain unmet) purposes effectively.

Middle East: Prestige Over Economics

Gulf Cooperation Council countries have collectively invested over \$40 billion in steel capacity over the past 15 years, with the UAE, Saudi Arabia, Qatar, and Oman all building integrated facilities. These investments occurred despite limited iron ore resources, extreme energy intensity in desert climates, and small domestic markets that cannot absorb production volumes economic for modern facilities.



Emirates Steel in Abu Dhabi operates at 60-70% capacity utilisation, requires ongoing government support, and generates returns far below the UAE's sovereign wealth fund benchmarks. Saudi Arabia's Hadeed facility similarly depends on subsidised energy and captive demand from government construction projects to maintain operations. Neither facility meaningfully contributes to economic diversification or employment generation - the ostensible development objectives justifying their construction.

The Gulf states' substantial financial resources enable them to sustain economically marginal steel industries indefinitely, but the opportunity costs remain enormous. The capital invested in steel could have instead accelerated renewable energy development, funded education infrastructure, or supported economic diversification initiatives with far superior development outcomes.

Southeast Asia: Mixed Results

Vietnam and Indonesia represent intermediate cases, pursuing steel development with mixed results. Vietnam's steel capacity has expanded from 5 million tonnes in 2000 to over 30 million tonnes by 2024, driven by construction boom demand and export opportunities. However, the industry faces increasing challenges from carbon border adjustments, Chinese competition, and domestic environmental concerns that threaten its economic viability.

Indonesia's approach - focusing primarily on stainless steel production using domestic nickel resources - demonstrates more strategic coherence. The country possesses genuine comparative advantage in nickel-based stainless steel, operates at higher capacity utilisation, and generates superior returns compared to Vietnam's commodity-focused expansion. The Indonesia case suggests that resource-advantaged specialty production may justify investment in ways that comprehensive commodity capacity does not.

Africa: Repeated Failures

African countries have attempted steel industry development for over 50 years with consistent failure.

- Nigeria's Ajaokuta Steel Company consumed over \$8 billion and never reached commercial production.
- South Africa's industry survives primarily through protected captive markets rather than genuine competitiveness.
- Kenya and other countries have pursued steel projects that have struggled with high costs and competitiveness issues; as well as uncertain fiscal and development benefits.

The African experience illustrates particularly clearly the mismatch between development aspirations and steel industry realities. The capital absorbed by failed or marginal steel projects could have funded infrastructure, education, and renewable energy investments with transformative development impacts. The persistence of steel development efforts despite repeated failures reflects the power of symbolic politics over economic rationality in industrial policy.



The Singapore Alternative: Prosperity Without Comprehensive Steel Production

The existence of highly prosperous economies without comprehensive domestic steel industries provides perhaps the most compelling evidence against the development orthodoxy. Singapore, Luxembourg, and certain Nordic countries demonstrate that economic prosperity, industrial sophistication, and even military capability do not require comprehensive domestic steel production.

Singapore: From Developing to Developed Without Steel

Singapore's development trajectory from the 1960s to present achieved per capita GDP exceeding \$65,000 without ever establishing steel production capacity. The country deliberately rejected heavy industry in favour of services, electronics, petrochemicals, and digital economy activities - sectors offering superior returns on scarce capital and limited labour resources.

Singapore's approach to strategic materials illustrates the viability of alternatives to domestic production. The country maintains strategic stockpiles of essential materials including specialty steels, diversifies supplier relationships across multiple countries, and develops deep financial markets that enable hedging and supply chain management. These measures provide material security at costs orders of magnitude below building domestic production capacity.

The Singapore model demonstrates that prosperity derives from productive deployment of capital and labour rather than specific industrial activities. The country's development success rests on education investment, infrastructure quality, institutional effectiveness, and integration with global supply chains - none of which require steel production and all of which benefit from not wasting capital on uncompetitive heavy industry.

Nordic Examples: Selective Specialisation

Finland, Denmark, and Norway demonstrate that even resource-rich countries with historical mining industries can prosper without comprehensive steel sectors.

- Finland shut down most integrated steel capacity, focusing instead on specialty stainless steel (Outokumpu) where it maintains technological advantages.
- Denmark never developed significant steel capacity, focusing on value-added manufacturing and services.
- Norway's small steel sector (supplied by Celsa; now owned by Seven GI, the Czech investment fund) serves primarily domestic construction demand without attempting export-oriented expansion.

These countries' development strategies prioritise education, technology, and specialisation in activities offering genuine comparative advantages. None pursue steel self-sufficiency, all import substantial steel volumes, and all achieve superior development outcomes compared to countries investing heavily in comprehensive steel industries.



Policy Recommendations: Import Commodity, Invest Elsewhere

The evidence presented suggests that most developing economies would achieve superior development outcomes by forgoing comprehensive steel industry development in favour of alternative capital deployment. The following policy framework offers a viable alternative to the development orthodoxy:

1. Strategic Segmentation of Steel Requirements

Governments should rigorously distinguish between commodity steel (99% of requirements) and strategic specialty steel ([one percent of requirements](#)), applying fundamentally different approaches to each category. Commodity steel should be procured through open competitive international markets, maximising economic efficiency and cost-effectiveness. Strategic specialty steel should be addressed through targeted stockpiling, dual-source supply contracts, and production partnerships that secure access without requiring comprehensive industry development.

This segmentation requires resisting political pressure to justify comprehensive steel industries through overstated strategic necessity claims. Military and infrastructure planners should be required to specify actual strategic steel requirements with technical precision, preventing the confusion of genuine security needs with prestige-driven industrialisation objectives.

2. Opportunity Cost Analysis for All Major Industrial Projects

Major industrial development proposals should undergo rigorous opportunity cost analysis comparing projected returns against alternative investments of equivalent capital. For steel projects, this requires comparing \$1,500 per tonne capital costs against renewable energy (\$2,000 per kilowatt), digital infrastructure (\$750 per household), transport infrastructure (\$5 million per kilometre), and education (\$15,000 per student per year).

Such analyses should employ realistic demand projections, appropriate discount rates reflecting true costs of capital, and comprehensive accounting for environmental compliance costs and carbon pricing exposure. The frequent use of subsidised capital costs, optimistic demand assumptions, and ignored environmental costs in steel project evaluations produces systematically misleading conclusions that have justified numerous regrettable investments.

3. Carbon-Constrained Investment Frameworks

All major industrial investments should be evaluated within explicit carbon budget constraints aligned with Paris Agreement commitments. For most developing economies, remaining carbon budgets cannot accommodate 30-year commitments to high-emission steel production while meeting climate objectives. Investment frameworks should explicitly price carbon at levels reflecting long-term regulatory trajectories (€80-100 per tonne by 2030, €150-200 by 2040) rather than the current absence of carbon pricing in most developing economies.



This approach would systematically favour renewable energy, digital infrastructure, and low-emission manufacturing over steel and other carbon-intensive industries - an outcome consistent with both climate imperatives and economic efficiency once environmental costs are properly accounted for.

4. Trade Policy Focused on Efficiency, Not Self-Sufficiency

Trade policy should prioritise economic efficiency and consumer welfare over self-sufficiency objectives that impose enormous costs for negligible security benefits. This means maintaining open steel import regimes, resisting protectionist pressure from uncompetitive domestic producers, and recognising that prosperity derives from productive capital deployment rather than specific industrial activities.

Countries should negotiate free trade agreements with multiple steel-producing regions, diversifying supply sources and creating competitive pressure that benefits downstream industries. Singapore and Nordic countries employ such approaches, achieving material security through diversification rather than expensive domestic production.

5. Targeted Support for Genuine Comparative Advantage

Where countries possess genuine comparative advantages in specific steel products - typically resource-based advantages like Indonesia's nickel for stainless steel - targeted support may be justified. However, such support should be limited to activities where long-term competitiveness is achievable without permanent protection, subject to sunset provisions, and evaluated against opportunity costs of alternative resource use.

The distinction between infant industry support (temporary assistance to achieve scale and capability) and permanent protection of uncompetitive industries must be rigorously maintained. Too many developing economy steel industries have remained perpetual infants requiring ongoing support decades after establishment, revealing that genuine competitiveness was never achievable.

Conclusion: Rethinking Steel's Role in Development

The conventional wisdom that developing economies require domestic steel industries as foundations for industrialisation and prosperity deserves fundamental reconsideration. The capital opportunity costs are enormous, the environmental lock-in conflicts directly with climate imperatives, the employment generation claims are vastly overstated, and the strategic necessity arguments apply to less than 1% of steel consumption that can be addressed through far less expensive targeted approaches.

Countries pursuing comprehensive steel industry development are typically making costly strategic errors driven by prestige politics and outdated development models rather than rigorous economic analysis. The capital absorbed by steel industries could generate 3-7 times more employment, superior economic returns, and transformative development impacts if invested instead in education, digital infrastructure, renewable energy, or transport systems.



The existence of highly prosperous economies without large-scale steelmaking - Singapore, Luxembourg, and certain Nordic countries - demonstrates conclusively that steel production is not necessary for development success. These countries achieved prosperity through productive capital deployment, education investment, and specialisation in activities offering genuine comparative advantages rather than pursuing self-sufficiency in commodity materials.

For most developing economies, the optimal steel strategy is remarkably straightforward: import commodity steel through competitive international markets (capturing efficiency gains from global overproduction), maintain strategic stockpiles of specialty materials (addressing legitimate security concerns at minimal cost), and invest scarce capital in education, infrastructure, and technology (generating superior development returns). This approach maximises economic efficiency, minimises environmental damage, and avoids the enormous opportunity costs of building steel industries that serve symbolic rather than substantive development purposes.

The steel development orthodoxy persists primarily because questioning it requires challenging powerful political narratives about industrial modernity, national strength, and development pathways. However, development policy should be driven by evidence of what actually generates prosperity rather than emotionally satisfying but economically destructive assumptions about steel's role in development. The Singapore alternative demonstrates a far more promising pathway to prosperity - one that developing economies ignore at their peril.

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Sources and Notes:

¹ [OECD](https://www.oecd.org/en/about/news/press-releases/2025/05/surging-excess-capacity-threatens-steel-market-stability-employment-and-decarbonisation-plans.html) (May 2025). *Surging Excess Capacity Threatens Steel Market Stability, Employment and Decarbonisation Plans*. Paris: OECD. Available at: <https://www.oecd.org/en/about/news/press-releases/2025/05/surging-excess-capacity-threatens-steel-market-stability-employment-and-decarbonisation-plans.html>. The analysis projects global steel excess capacity will reach 721 million tonnes by 2027, representing approximately 37% of global production capacity and creating severe profitability pressures across the industry.

² World Steel Association (2024). *Steel's Contribution to a Low Carbon Future and Climate Resilient Societies*. Brussels: worldsteel. The report projects that 40% of current [BF-BOF](#) capacity will require replacement or closure by 2050 to meet Paris Agreement targets, with developing economies facing particularly acute stranded asset risks due to recent capacity additions.

³ Asian Development Bank (2019). *Meeting Asia's Infrastructure Needs*. Manila: [ADB](#). The comprehensive infrastructure study finds that transport infrastructure investments generate economic returns of 12-18% in developing Asia, compared to 4-7% for heavy industry investments, with superior employment and productivity spillovers across all economic sectors.

⁴ World Bank (2017). *Trouble in the Making? The Future of Manufacturing-Led Development*. Washington DC: World Bank. The analysis finds that education investments generate real returns of 20-25% in developing economies, compared to 4-6% for steel and other commodity manufacturing, with education's returns compounding over generations through human capital accumulation.



⁵ International Energy Agency (2023). *Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach*. Paris: [IEA](#). The roadmap requires steel sector emissions reductions of 60% by 2040 and near-zero by 2050, creating substantial stranded asset risks for conventional capacity commissioned after 2025, particularly in developing economies lacking carbon capture infrastructure or clean hydrogen access.

⁶ International Renewable Energy Agency (2020). *Renewable Energy and Jobs — Annual Review 2020*. Abu Dhabi: [IRENA](#). The employment analysis finds renewable energy investments create 15-20 jobs per \$1 million invested compared to 5-7 for steel, with renewable energy jobs offering superior skills development and wage growth trajectories in developing economies.



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