Canadian Steel Research and Industrial Policy: Decarbonization in a Resource-Rich Context with Federal-Provincial Coordination

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November 2025

Abstract

This document examines Canada's steel research and industrial policy framework as it navigates the transition toward net-zero emissions by 2050. With approximately 12.8 million tonnes of annual crude steel production concentrated primarily in Ontario, Canada represents a unique case study combining resource abundance (iron ore, renewable energy), technological sophistication, and a federal-provincial governance structure that requires coordination across jurisdictions. The analysis explores Canada's distinctive advantages including world-leading low-carbon intensity production, vast renewable energy potential, and high-quality iron ore reserves that position the country as a potential global supplier of "green iron." The document examines major decarbonization projects currently underway, the policy architecture including carbon pricing and investment tax credits, and the strategic opportunity for Canada to transition from iron ore exporter to green iron producer. Key challenges include managing trade tensions with the United States, coordinating federal and provincial policies, and mobilizing the substantial capital required for industrial transformation while maintaining competitiveness in global markets.

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1 Strategic Context: Canadian Steel in Global Perspective

1.1 Production Landscape and Geographic Concentration

Canadian steel production exhibits strong geographic concentration in Ontario:

2024 Production: Approximately 12.8 million tonnes crude steel

- Ontario: 90% of Canadian production
- Quebec: 5% (primarily Rio Tinto specialty production)
- Other provinces: 5%

Global share: Approximately 0.7% of world production

Technology distribution:

- Integrated BF-BOF: 70% of capacity (three major plants)
- Electric arc furnace: 30% of capacity
- Transition underway: Two major integrated mills converting to H2-DRI-EAF

Major producers:

- ArcelorMittal Dofasco (Hamilton, Ontario): 4.05 MT capacity
- Algoma Steel (Sault Ste. Marie, Ontario): 3.2 MT capacity
- Stelco (Haldimand County, Ontario): 2.5 MT capacity (acquired by Cleveland-Cliffs 2024)
- Rio Tinto Iron & Titanium (Sorel-Tracy, Quebec): 0.6 MT capacity

1.2 Economic and Strategic Significance

Direct employment: Approximately 22,000 workers in steel production

Indirect employment: Estimated 100,000+ in steel value chains

Strategic importance:

- Critical input for automotive, construction, energy infrastructure sectors
- Three largest industrial CO_2 emitters in Ontario are all steel plants
- Account for 40% of Ontario's industrial greenhouse gas emissions
- National security considerations for domestic steel supply

Trade position:

- Integrated North American market with strong US dependencies
- Export vulnerabilities: US tariffs imposed 50% duties (June 2025)
- Scrap export: 4.9 million tonnes (2024), indicating surplus availability
- Potential future role: Green iron exporter to global markets

1.3 Emissions Profile and Climate Challenge

Current emissions: Approximately 13.1 million tonnes CO_2 annually (2023)

- 2% of Canada's total greenhouse gas emissions
- Equivalent to approximately 3 million gasoline-powered vehicles
- 40% of Ontario's industrial emissions

Climate targets:

- Federal commitment: Net-zero by 2050
- Industry target: 40% reduction by 2030 (from 2022 baseline)
- Projected reduction: 5 megatonnes CO_2 between 2022-2030
- Long-term goal: 80-95% emissions reductions by mid-century

Current status:

- Canada's steel already has among lowest carbon intensity globally for both BF-BOF and EAF routes
- Major transformation projects underway at two of three integrated mills
- Decarbonization pathway alignment with net-zero trajectory

2 Policy Architecture for Steel Decarbonization

2.1 Multi-Level Governance Structure

Canada's steel policy operates within a complex federal-provincial framework:

2.1.1 Federal Level

Natural Resources Canada (NRCan):

- Industrial energy efficiency programs
- CanmetENERGY research collaboration with industry
- Hydrogen strategy development and coordination
- Clean technology funding programs

Environment and Climate Change Canada (ECCC):

- Carbon pricing policy (federal backstop and equivalency agreements)
- Emissions reporting and regulatory oversight
- Climate plan development and monitoring

Innovation, Science and Economic Development Canada (ISED):

- Strategic Innovation Fund for large capital projects
- Regional economic development programs
- Technology commercialization support

Finance Canada:

- Investment tax credits for clean technology
- Carbon pricing revenue management
- Trade policy and tariff negotiations

2.1.2 Provincial Level (Ontario Focus)

Ministry of Environment, Conservation and Parks (MECP):

- Emissions Performance Standards (EPS) program
- Environmental approvals and permitting
- Complementary carbon pricing mechanisms

Ministry of Economic Development, Job Creation and Trade:

- Industry support programs and co-investment
- Economic competitiveness initiatives
- Skills development and workforce transition

2.1.3 Industry Association

Canadian Steel Producers Association (CSPA):

- Industry representation and policy advocacy
- Research coordination and technology roadmap development
- Climate Call for Action (voluntary industry commitment)
- Data collection and benchmarking

2.2 Policy Instruments and Frameworks

2.2.1 Carbon Pricing System

Greenhouse Gas Pollution Pricing Act (2018):
Federal carbon pricing with two components:

- Fuel charge on fossil fuels
- Output-Based Pricing System (OBPS) for large industrial emitters

OBPS mechanism for steel:

- Performance standards based on emissions intensity benchmarks
- Credits generated when emissions below standard
- Charges applied when emissions exceed standard
- Designed to incentivize efficiency while protecting competitiveness
- Annual stringency increases: 2% (2019-2023), then 2.4% (2024), then 1.5% (2025-2030)

Ontario Emissions Performance Standards (EPS):

- Provincial program deemed equivalent to federal OBPS
- Sector-specific standards for steel facilities
- Reduced stringency factors for "clean steel production" facilities
- Ongoing refinement to support decarbonization without exceeding federal costs

Carbon pricing trajectory:

- 2024: $80/tonne CO_2e
- 2030: $170/tonne CO_2e (federal plan)
- Revenue recycling: Combination of household rebates and industrial support

2.2.2 Investment Tax Credits

Clean Technology Investment Tax Credit (2024):

- 30% credit for eligible clean technology equipment
- Covers equipment for renewable energy generation, storage, clean hydrogen production
- Designed to compete with US Inflation Reduction Act incentives

Carbon Capture, Utilization and Storage (CCUS) Investment Tax Credit:

- 60% credit for direct air capture equipment
- 50% credit for other carbon capture equipment
- 37.5% credit for transportation and storage infrastructure
- Applicable to steel sector emissions capture projects

2.2.3 Direct Government Investment

Strategic Innovation Fund:

- Large-scale industrial transformation projects
- Repayable and non-repayable contributions
- Co-investment model with private sector

Major steel decarbonization commitments (Federal & Ontario):

- ArcelorMittal Dofasco: $1.8 billion project, $400+ million government support
- Algoma Steel: $700+ million project, $420 million government loans and grants
- Total government commitments: Approximately $2 billion for Ontario steel sector

2.2.4 Green Procurement Policy

Federal green procurement standards (2024):

- Construction projects required to use low-emissions steel
- Preference for domestically-produced steel meeting emissions criteria
- Federal government as largest Canadian purchaser creating demand signal
- Described as "huge step" by industry given procurement scale

3 Technology Pathways and Major Projects

3.1 Hydrogen-Based Direct Reduction (H2-DRI-EAF Route)

This represents the primary decarbonization pathway for Canadian integrated mills.

3.1.1 ArcelorMittal Dofasco (Hamilton, Ontario)

Project scope:

- Total investment: $1.8 billion
- 2.5 million tonne per year DRI plant using natural gas (transitioning to hydrogen)
- Electric arc furnace installation
- Blast furnace decommissioning
- Timeline: Launched October 2022, completion 2028

Emissions impact:

- Target: 3 million tonnes CO_2 reduction annually (60% reduction)
- Pathway to eventual hydrogen-based near-zero emissions
- Represents largest single decarbonization project in Canadian steel

Technology approach:

- Initial phase: Natural gas-based DRI
- Future phase: Hydrogen blending increasing to 100% hydrogen
- Dependent on development of regional hydrogen supply infrastructure

3.1.2 Algoma Steel (Sault Ste. Marie, Ontario)

Project scope:

- Total investment: $700+ million
- Complete shutdown of blast furnace and coke ovens
- Installation of electric arc furnace(s)
- Transition to 100% scrap-based and DRI-based production
- First steel produced from EAF: July 2025

Emissions impact:

- Target: 70% emissions reduction
- 3 million tonnes CO_2 reduction annually
- Capacity increase: Production up 33% while reducing emissions

Employment impact:

- Fewer workers required than blast furnace operations
- Workforce transition and retraining programs implemented
- Social implications managed through government support programs

Trade pressures:

- US tariffs (50% imposed June 2025) accelerating transition timeline
- Company accessing emergency federal/provincial loans ($500 million) for liquidity
- Demonstrating how trade policy impacts industrial transformation pace

3.2 Biochar and Alternative Carbon Sources

3.2.1 Rio Tinto Iron & Titanium (Sorel-Tracy, Quebec)

Project scope:

- Conversion from coal to biochar as reducing agent
- Partnership with US-based Aymium for biochar production
- Biochar plant construction at former pulp and paper mill site in Quebec
- Expected commissioning: End of 2025

Emissions impact:

- 70% emissions reduction from biochar substitution
- Additional 30% reduction target through Blue-Smelting technology
- Blue-Smelting: Preheating material before melting and steel gas utilization
- Pilot plant operational: 40,000 tonne/year capacity

Optimal strategy rationale:

- Small production volumes (0.6 MT) make biochar approach economically viable
- Demonstrates diversified technology pathways appropriate to facility scale
- Leverages Quebec's forestry industry waste streams

3.3 Scrap-Based Electric Arc Furnace Expansion

Canadian scrap availability:

- Scrap collection volumes exceed current domestic needs
- 4.9 million tonnes exported (2024)

- Sufficient supply to support expanded EAF production
- Quality suitable for most steel grades

Implications:

- Both Algoma and ArcelorMittal projects will utilize scrap in EAFs
- Circular economy benefits beyond direct emissions reductions
- Potential to increase EAF share of national production from 30% to 50%+

3.4 Research and Development Priorities

CanmetENERGY collaboration:

- Federal research facility partnership with steel companies
- Focus areas: Energy efficiency, emissions reduction, hydrogen integration
- Technology demonstration and validation

Canadian Carbonization Research Association:

- Industry-led research consortium
- Coking coal alternatives and process optimization
- Knowledge sharing across Canadian producers

Near-term operational excellence projects:

- Algoma identified projects for 79,000 tonne CO_2 reduction
- State-of-the-art manufacturing practices
- Energy management and process optimization
- Incremental improvements complementing major capital projects

4 Strategic Opportunity: Canada as Green Iron Exporter

4.1 Resource Endowments and Competitive Advantages

Canada possesses unique combinations of resources positioning it as potential global green iron supplier:

Iron ore reserves:

- Approximately 6 billion tonnes proven reserves
- High-quality ore suitable for direct reduction
- Existing mining infrastructure and expertise
- Current position: 10th largest iron ore producer globally

Renewable energy potential:

- 6th globally in renewable energy generation capacity
- Vast hydroelectric resources (primary current source)
- Significant wind power potential, especially in regions near iron ore deposits
- Renewable energy costs competitive with fossil alternatives

Hydrogen production potential:

- Green hydrogen from electrolysis using renewable electricity
- Abundant freshwater resources for electrolysis
- Existing natural gas infrastructure potentially repurposable for hydrogen

4.2 Green Iron Production Economics

Recent research examining Canada's green iron potential:

Cost competitiveness:

- Estimated production costs: $430-520 USD per tonne green iron
- Among most competitive globally, comparable to United States
- Lower costs than most European and Asian alternatives
- Advantage driven by low-cost renewable electricity and domestic ore

Market opportunity:

- Global steel industry seeking reliable low-emissions iron supply
- EU Carbon Border Adjustment Mechanism (CBAM) creating demand for low-carbon inputs
- Clean procurement rules in multiple jurisdictions favoring green inputs
- Potential markets: Central/Eastern Europe, UK, Japan, South Korea

4.3 Strategic Vision: From Ore Exporter to Green Iron Exporter

Current trade pattern:

- Canada exports iron ore to China, Japan, and other markets
- Japan imports $778 million (113 billion yen) Canadian iron ore annually
- Low value-added commodity export

Transformation opportunity:

- Value addition: Green iron (DRI/HBI) commands premium over ore
- Emissions reduction: Up to 105 million tonnes CO_2 annually (domestic + export impacts)
- Economic development: Green jobs, advanced manufacturing, technology leadership
- Geopolitical: Trusted supplier to allied nations seeking supply diversification

International precedents:

- Sweden: SSAB and H2 Green Steel pioneering commercial green steel production
- Australia: Multiple green iron projects in development phase
- Canada competitive with these first-movers in resource endowments

4.4 Implementation Requirements

Infrastructure development:

- Hydrogen production facilities at scale
- DRI/HBI plants near iron ore deposits
- Renewable energy generation expansion
- Port and logistics infrastructure for green iron export

Policy enablers:

- Investment incentives for green iron production
- Hydrogen strategy implementation and coordination
- International trade agreements recognizing low-carbon products
- Carbon accounting and certification systems

Industry partnerships:

- Example: Nippon Steel 30% stake in Champion Iron's Kami project
- Potential for integrated value chains with international steelmakers
- Technology transfer and knowledge sharing
- Long-term offtake agreements providing investment certainty

5 Coordination Challenges and Federal-Provincial Dynamics

5.1 Constitutional Division of Powers

Canada's federal structure creates unique coordination requirements:

Federal jurisdiction:

- International trade and treaties
- Criminal law (including environmental enforcement)
- National carbon pricing framework
- Federal funding programs and tax credits

Provincial jurisdiction:

- Natural resources management
- Property and civil rights (including most environmental regulation)
- Local works and undertakings
- Provincial crown corporations and economic development

Shared/overlapping areas:

- Environmental protection
- Economic development
- Research and innovation
- Infrastructure investment

5.2 Ontario-Federal Coordination

Areas of alignment:

- Shared commitment to steel sector transformation
- Co-investment in major decarbonization projects
- Recognition of competitiveness and carbon leakage risks
- Support for clean procurement and green steel markets

Tensions and negotiations:

- Ontario EPS stringency relative to federal requirements
- Concerns about federal carbon pricing increasing faster than provincial tolerance
- Distribution of fiscal burden for industrial support
- Timing and pace of regulatory changes

CSPA advocacy for policy coherence:

- Provincial standards should not exceed federal carbon compliance costs
- Recognition that all Canadian producers engage in clean production practices
- Request for adequate transition timelines for new sector-based standards
- Emphasis on level playing field across provinces

5.3 Inter-Provincial Considerations

Ontario dominance:

- 90% of production concentrated in one province
- Federal policies effectively targeted at Ontario steel sector
- Other provinces limited direct stakes in outcomes

Quebec differentiation:

- Smaller specialty production with different economics
- Provincial electricity grid already low-carbon (hydroelectric)
- Quebec cap-and-trade system linked to California/Washington
- Distinct regulatory environment from Ontario

6 International Dimensions and Trade Context

6.1 United States-Canada Steel Trade Relations

Integrated North American market:

- CUSMA/USMCA framework governing steel trade
- Deeply integrated supply chains across border
- Canadian steel inputs to US manufacturing

Tariff challenges (2025):

- US imposed 50% tariffs on Canadian steel (June 2025)
- Significant competitiveness impact on Canadian producers
- Algoma accessing emergency government loans for liquidity
- High-level diplomatic engagement: PM-President meetings seeking resolution

Policy responses:

- Accelerated green steel transition as strategic repositioning
- Emphasis on North American supply chain security arguments
- Potential for coordinated North American decarbonization approach

6.2 Comparison with US Industrial Policy

US Inflation Reduction Act (IRA) impacts:

- Generous tax credits creating competitive asymmetry
- Canadian policy response: Matching investment tax credits
- Risk of investment diversion to US absent Canadian incentives
- North American competition for clean technology manufacturing

Canadian response strategy:

- Clean Technology Investment Tax Credit designed to compete with IRA
- CCUS tax credits matching US 45Q incentives
- Emphasis on Canadian advantages: Resources, energy, political stability

6.3 Global Market Positioning

Competition dynamics:

- Global steel overcapacity (primarily China) depressing prices
- Carbon-intensive imports undercutting higher-cost Canadian production
- Canadian vulnerability due to relatively small scale

Differentiation strategy:

- Already among lowest carbon intensity producers globally
- Transformation to green steel as premium market positioning
- Emphasis on quality, reliability, and sustainability
- Potential green iron export markets beyond traditional steel exports

CBAM implications:

- EU Carbon Border Adjustment Mechanism as potential market access tool
- Low-carbon Canadian steel advantaged in EU market
- Canada has not implemented reciprocal CBAM as of 2024
- Ongoing dialogue: PM Trudeau-EC President von der Leyen discussions (September 2024)

6.4 Technology Partnerships and Knowledge Exchange

International collaboration opportunities:

- Learning from Swedish green steel pioneers (SSAB, H2 Green Steel)
- Technology exchange with European steel sector
- Potential partnerships with Japanese steelmakers (existing iron ore trade relationships)
- Participation in international steel decarbonization initiatives

7 Future Outlook and Critical Success Factors

7.1 Scenarios for Canadian Steel (2025-2050)

7.1.1 Optimistic: Green Steel Leader

Pathway:

- 2030: 40% emissions reduction achieved, major projects completed successfully
- 2035: Hydrogen infrastructure scaled, transition to 100% H2-DRI at converted mills
- 2040: Green iron production for export markets established
- 2050: Near-complete decarbonization, capacity maintained 12-14 MT
- Outcome: Technology and sustainability leadership, premium market positioning

7.1.2 Pessimistic: Competitiveness Crisis

Pathway:

- 2030: Projects delayed, cost overruns, hydrogen infrastructure inadequate
- 2035: US trade barriers persist, CBAM benefits fail to materialize
- 2040: One or more major facilities closed due to uncompetitive economics
- 2050: Residual production 6-8 MT, heavy import dependence
- Outcome: Industrial decline, employment losses, strategic capability erosion

7.1.3 Realistic: Managed Transformation

Pathway:

- 2030: 30-35% emissions reduction, projects completed with some delays and cost escalation
- 2035: Hydrogen blending operational, gradual scale-up toward 100% H2
- 2040: Green iron pilot projects, modest export volumes
- 2050: 70-80% emissions reduction, capacity 10-12 MT
- Outcome: Successful but challenging transformation, maintained competitiveness with government support

7.2 Critical Success Factors

7.2.1 Hydrogen Infrastructure Development

Requirements:

- Large-scale green hydrogen production facilities
- Pipeline or transportation infrastructure to steel plants
- Competitive hydrogen pricing ($2-3/kg target for steel competitiveness)
- Coordination with broader hydrogen economy development

Challenges:

- Current hydrogen costs exceed viable levels for steel
- Infrastructure investment requiring government support
- Chicken-and-egg problem: Demand needed to justify infrastructure, infrastructure needed to enable demand
- Regional strategy coordination: Federal, provincial, municipal levels

7.2.2 Sustained Policy Support and Investment

Financial requirements:

- Major projects completed: $2+ billion government commitments already made
- Future needs: Hydrogen infrastructure, subsequent facility conversions, ongoing R&D
- Balance: Public support justified for first-movers, but long-term reliance on subsidies unsustainable

Policy stability:

- Consistent carbon pricing trajectory providing investment certainty
- Multi-year funding commitments surviving political cycles
- Federal-provincial coordination maintaining alignment

7.2.3 Market Development for Green Steel

Domestic demand:

- Federal green procurement creating initial market
- Provincial and municipal adoption of similar standards
- Private sector willingness to pay premium for low-carbon steel
- Automotive sector as key customer segment

Export markets:

- Resolution of US trade barriers
- CBAM creating EU market access advantages
- Green iron export opportunities in Asia and Europe
- International recognition of Canadian low-carbon production

7.2.4 Workforce Transition and Social License

Employment impacts:

- EAF operations less labor-intensive than blast furnaces
- Retraining programs for displaced workers
- New skills requirements for hydrogen-based production

- Community economic diversification in steel-dependent regions

Social acceptance:

- Public understanding of transformation necessity
- Labor union engagement and support
- Regional economic development strategies
- Just transition principles in policy implementation

7.2.5 Trade Policy and Competitiveness Protection

Immediate priorities:

- Resolution of US steel tariffs
- Protection against carbon-intensive imports
- Consideration of Canadian CBAM or equivalent mechanism
- Trade remedy measures against dumped/subsidized imports

Long-term strategy:

- International agreements recognizing low-carbon steel
- Standards harmonization with key trading partners
- Strategic alliances with like-minded steel-producing nations
- Technology export opportunities complementing steel trade

8 Conclusions

Canada's steel decarbonization strategy represents a distinctive approach shaped by the country's unique combination of resource endowments, geographic concentration, and federal-provincial governance structure. Several key conclusions emerge from this analysis:

First, Canada enters the decarbonization challenge from a position of relative strength. Canadian steel production already exhibits among the lowest carbon intensity globally, providing a foundation for transformation rather than crisis. The country's vast renewable energy resources, high-quality iron ore reserves, and technological capacity position it uniquely to become not just a producer of green steel for domestic consumption, but potentially a global supplier of green iron to other steel-producing nations.

Second, the pace and scale of transformation underway is substantial. With two of three major integrated mills converting to hydrogen-ready direct reduction and electric arc furnaces, representing over $2.5 billion in capital investment and the potential elimination of 6 million tonnes of annual CO_2 emissions, Canada is demonstrating concrete progress toward its 2030 and 2050 climate targets. The completion of these projects by 2028 will fundamentally reshape the Canadian steel industry.

Third, government policy and investment have been critical enablers. The combination of carbon pricing creating transformation incentives, investment tax credits reducing capital costs, and direct government co-investment in major projects reflects a coordinated approach across federal and provincial jurisdictions. The approximately $2 billion in public funding committed to date represents substantial but likely necessary support for first-mover facilities facing technological and market uncertainties.

Fourth, significant challenges remain. Hydrogen infrastructure development represents the most critical long-term uncertainty. Without large-scale, cost-competitive green hydrogen supply, the full potential of the H2-DRI pathway cannot be realized. Current hydrogen costs exceed economically viable levels for steel production, and the infrastructure investment required is measured in billions of dollars across production, transportation, and distribution systems.

Fifth, trade policy and market development will determine commercial viability. The imposition of US tariffs in 2025 demonstrates the vulnerability of Canadian producers to policy decisions in their primary export market. Conversely, the development of green steel procurement standards, both domestically and internationally, creates potential premium markets that could justify the higher costs of low-carbon production. The EU's Carbon Border Adjustment Mechanism, in particular, represents a potential opportunity for Canadian producers if they can demonstrate and certify their low emissions intensity.

Sixth, the federal-provincial governance structure creates both strengths and complexities. The concentration of production in Ontario simplifies coordination relative to more dispersed geographies, but the constitutional division of powers requires ongoing negotiation between federal and provincial governments on carbon pricing stringency, environmental standards, and fiscal burden-sharing. The Canadian Steel Producers Association's advocacy for policy coherence reflects industry concerns about potential misalignment between jurisdictional levels.

Finally, Canada's transformation carries implications beyond its borders. As a middle-power with significant resource endowments, technological sophistication, and climate ambitions, Canada's success or failure in steel decarbonization provides a test case for other resource-rich nations. The potential transition from commodity iron ore exporter to value-added green iron supplier represents an economic development model with relevance for countries including Australia, Brazil, and others with similar endowments.

The coming decade will be decisive. By 2030, the major transformation projects will be operational, hydrogen infrastructure development will be advancing or stalled, and market conditions for green steel will be clarifying. Success requires sustained policy commitment, continued technological progress, favorable trade environments, and the development of markets willing to value low-carbon steel sufficiently to support the economics of production.

For the global steel research community, the Canadian experience offers valuable lessons in the practical implementation of hydrogen-based steelmaking at commercial scale, the coordination challenges of multi-jurisdictional decarbonization policy, and the strategic opportunities available to resource-rich nations in the emerging green steel economy. Continued analysis and knowledge exchange will benefit all nations and companies navigating the complex transition toward net-zero steel production.

Acknowledgments

This document was prepared as part of the comparative steel policy analysis for the ESTEP 2025 Udine conference. The analysis draws on publicly available information from government sources, industry reports, and media coverage. Errors and omissions remain the responsibility of the author. Comments, corrections, and additional insights from Canadian steel researchers, policymakers, and industry practitioners are welcomed and will inform future revisions.

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