European Union Steel Research and Industrial Policy: Coordinating Decarbonization Across 27 Member States

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Abstract

This document examines the European Union's steel research and industrial policy framework as the coordinating mechanism for decarbonization across Europe's diverse steel industries. With 126.5 million tonnes of annual crude steel production distributed across 27 member states, the EU faces the challenge of harmonizing climate ambitions with industrial competitiveness while respecting subsidiarity principles. This analysis explores the Research Fund for Coal and Steel (RFCS) transition to Horizon Europe, the Innovation Fund supporting breakthrough decarbonization projects, the Carbon Border Adjustment Mechanism (CBAM) as the EU's flagship competitiveness protection tool, and the complex interplay between EU-level policy frameworks and national implementation strategies. The document highlights how the EU's steel policy exemplifies broader tensions between supranational climate governance, national industrial sovereignty, and the imperative to maintain strategic industrial capabilities in an era of geopolitical competition.

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1 Strategic Context: EU Steel in Global Perspective

1.1 Production Landscape and Geographic Distribution

The European Union remains a major global steel producer despite decades of capacity decline:
2024 Production: 126.5 million tonnes crude steel

- Germany: 37.2 MT (29% of EU total)
- Italy: 20.0 MT (16%)
- France: 10.8 MT (9%)
- Spain: 11.9 MT (9%)
- Poland: 7.1 MT (6%)
- Other member states: 39.5 MT (31%)

Global share: Approximately 6.7% of world production (down from 25%+ in 1970s)
Technology distribution:

- Integrated BF-BOF: 60% of EU capacity
- Electric arc furnace: 40% of EU capacity
- Geographic pattern: Northern/Central Europe dominated by integrated mills, Southern Europe higher EAF share

1.2 Economic and Strategic Significance

Direct employment: Approximately 320,000 workers in steel production
Indirect employment: Estimated 1.5-2 million in steel value chains
Strategic importance:

- Foundation for automotive, construction, machinery, defense industries
- Critical for European manufacturing competitiveness
- Technology sovereignty concerns in era of geopolitical competition
- National security implications for defense steel supply

Trade position:

- Net importer of crude steel (imports exceed exports)
- Exporter of high-value specialty steels and downstream products
- Import penetration increasing from Asian producers
- Vulnerability to global overcapacity and trade distortions

1.3 Emissions Profile and Climate Challenge

Current emissions: Approximately 180-200 million tonnes CO_2 annually

- 11% of EU industrial emissions
- 4% of total EU greenhouse gas emissions
- Among hardest-to-abate industrial sectors

Climate targets:

- EU Green Deal: 55% emissions reduction by 2030 (vs. 1990 baseline)
- Climate neutrality by 2050
- Steel sector must achieve 80-95% emissions reductions
- Sectoral roadmaps under development

2 EU Policy Architecture for Steel

2.1 Multi-Level Governance Structure

EU steel policy operates across multiple jurisdictional levels:

2.1.1 Supranational (EU) Level

European Commission:

- DG GROW (Internal Market, Industry): Industrial policy leadership
- DG CLIMA (Climate Action): Emissions trading, climate targets
- DG ENER (Energy): Energy policy, hydrogen strategy
- DG COMP (Competition): State aid control, merger approval
- DG TRADE: Trade policy, safeguards, anti-dumping

European Parliament:

- Co-legislation with Council on major policy frameworks
- ITRE Committee: Industry, research, energy
- ENVI Committee: Environment and climate
- Scrutiny and amendment of Commission proposals

Council of the European Union:

- Member state representation and co-legislation
- Competitiveness Council: Industrial policy
- Environment Council: Climate and environmental regulation
- Qualified majority voting with national veto on some issues

2.1.2 National Level

Member state responsibilities:

- Implementation of EU frameworks
- National industrial and climate policies
- State aid within EU rules
- Ownership and governance of strategic companies
- National research funding complementing EU programs

2.1.3 Regional and Local

Subnational roles:

- Regional development and cohesion policy
- Planning and environmental permitting
- Skills development and labor market policies
- Innovation clusters and ecosystems

2.2 Policy Instruments and Frameworks

2.2.1 Research and Innovation Funding

Research Fund for Coal and Steel (RFCS) - Legacy Program:
Established 2002 from ECSC (European Coal and Steel Community) liquidation assets:

- Annual budget: €55 million from asset returns

- Support for pre-competitive steel research
- Co-funding: EU typically 40-50%, industry remainder
- Expiry: Original mandate through 2027

Horizon Europe Integration (2028+):
Transition of steel research into broader framework:

- Cluster 4: Digital, Industry and Space
- Cluster 5: Climate, Energy and Mobility
- Dedicated steel research budget under negotiation
- Enhanced co-funding rates (up to 70%) to maintain industry participation
- Concerns: Loss of steel-specific focus, administrative complexity

Clean Steel Partnership:
Public-private partnership launched 2021 under Horizon Europe:

- €300 million EU contribution (2021-2027)
- Industry co-funding commitment: €300+ million
- Focus: Breakthrough decarbonization technologies
- Participants: EUROFER, major steel companies, research institutions
- Projects: Hydrogen steelmaking, CCUS, circular economy, digitalization

2.2.2 Innovation Fund

Large-scale demonstration project support from ETS auction revenues:
Structure:

- Total envelope: €40+ billion (2020-2030)
- Funding for first-of-a-kind commercial demonstrations
- Large-scale calls: Projects >€7.5 million CAPEX support
- Small-scale calls: Projects <€7.5 million
- Steel sector: Priority area for funding

Steel projects funded:

- Salzgitter SALCOS (Germany): €725 million
- H2 Green Steel (Sweden): €143 million
- ArcelorMittal projects (France, Belgium, Spain): Multiple awards
- Total steel allocations: €2+ billion across multiple calls

Selection criteria:

- Innovation and GHG emissions reduction potential
- Technology readiness and maturity
- Replicability and scalability
- Financial viability and business model
- Implementation timeline and risk management

2.2.3 EU Emissions Trading System (ETS)

Carbon pricing as primary decarbonization driver:
Phase 4 (2021-2030):

- Annual cap reduction: 2.2% per year
- Free allocation declining toward phase-out
- Carbon leakage protection through free allowances

- Benchmarking based on best available technology
- Current carbon price: €60-90 per tonne CO_2 (volatile)

Implications for steel:

- Rising carbon costs incentivizing decarbonization investments
- Free allocation protecting competitiveness during transition
- Windfall profits for efficient producers selling surplus allowances
- Debate: Speed of free allocation phase-out relative to CBAM introduction

2.2.4 Carbon Border Adjustment Mechanism (CBAM)

Design and timeline:

Transitional period (2023-2025):

- Reporting requirements only, no financial obligations
- Data collection on embedded emissions of imports
- Refinement of methodology and systems

Implementation phase (2026+):

- Importers purchase CBAM certificates
- Certificate price tracks EU ETS price
- Deduction for carbon pricing in country of origin
- Gradual phase-in coordinated with free allowance phase-out

Coverage:

- Steel and iron (crude steel, semi-finished, downstream products)
- Cement, aluminum, fertilizers, electricity, hydrogen
- Potential expansion to additional sectors post-2030

Rationale:

- Prevent carbon leakage (production shifting to less regulated jurisdictions)
- Level playing field for EU producers facing carbon costs
- Incentivize global decarbonization
- Generate revenue for climate investments

Controversies:

- WTO compatibility: Legal challenges anticipated
- Administrative complexity: Burden for importers and customs
- Developing country concerns: Claims of protectionism
- Export competitiveness: CBAM only addresses imports, not EU exports

2.2.5 Industrial Strategy and Action Plans

European Green Deal Industrial Plan:

- Framework linking climate and industrial policy
- Simplification of state aid for green tech
- Skills development and workforce transition
- Trade policy and international partnerships

Steel Action Plan:

- Sectoral strategy addressing competitiveness and decarbonization
- Support for research and innovation
- Trade defense and fair competition
- Skills development and social transition
- Circular economy and resource efficiency

2.3 State Aid Framework

EU competition policy constrains but enables national support:

2.3.1 General Principles

Treaty prohibition:

- Article 107 TFEU: State aid generally prohibited as distorting competition
- Exceptions allowed for objectives of common interest
- Commission approval required for large aid measures
- Notification and transparency requirements

2.3.2 Temporary Crisis Frameworks

Energy crisis response (2022-2023):

- Temporary framework for state aid to energy-intensive industries
- Compensation for extraordinary energy costs
- Support for diversification away from Russian energy
- Extensions and adaptations ongoing

Green Deal Industrial Plan (2023+):

- Simplified approval for green investments
- Enhanced flexibility for member states
- Response to US Inflation Reduction Act competitive challenge
- Concerns about level playing field within EU (large vs. small states)

2.3.3 Important Projects of Common European Interest (IPCEI)

Hydrogen IPCEI:

- Multi-country strategic projects in hydrogen value chain
- Steel applications as priority area
- Flexibility on state aid rules for projects with EU-wide significance
- German, French, Italian, Spanish steel projects participating

3 Technology Pathways and Research Priorities

3.1 Hydrogen-Based Steelmaking

H2-DRI-EAF route: Primary decarbonization pathway for EU integrated mills:

- Direct reduction using hydrogen instead of natural gas
- Electric arc furnace melting of DRI
- Near-zero direct CO_2 emissions (with renewable electricity)
- Challenges: Hydrogen supply, cost, infrastructure

Major projects:

- Germany: Thyssenkrupp tkH2Steel, Salzgitter SALCOS
- Sweden: SSAB H2 Green Steel (commercial production 2026)
- France: ArcelorMittal Dunkerque hydrogen injection pilots
- Netherlands: Tata Steel IJmuiden DRI-EAF conversion plans
- Austria: Voestalpine H2FUTURE electrolyzer and DRI pilots

Research priorities:

- Optimization of hydrogen utilization in reduction process
- DRI quality control and consistency
- Hydrogen embrittlement mitigation in equipment and products
- Process integration and heat management
- Scale-up from pilot to commercial operation

3.2 Carbon Capture, Utilization and Storage (CCUS)

Rationale for EU context:

- Bridge technology for existing blast furnaces
- Addresses residual emissions in hydrogen routes
- Utilizes geological storage potential (North Sea, other)
- Coordinates with broader industrial cluster CCUS projects

Projects and initiatives:

- ArcelorMittal Carbon2Carb (Germany): Blast furnace gas to synthetic crude
- Porthos Project (Netherlands): Rotterdam industrial CCUS cluster
- Northern Lights (Norway): CO_2 transport and storage service
- Various national programs for capture technology development

Challenges:

- High capital and operating costs
- Energy penalty reducing plant efficiency
- Public acceptance of CO_2 storage
- Regulatory frameworks and long-term liability
- Limited contribution to deep decarbonization (80-90% capture rates)

3.3 Scrap-Based Steel and Circular Economy

EAF expansion opportunity:

- Current EU EAF share: 40%, potential to reach 50-60%
- Lower emissions (0.4-0.5 tonnes CO_2 per tonne vs. 2.0 for BF-BOF)
- Dependent on scrap availability and quality

Scrap supply considerations:

- EU generates 90 million tonnes scrap annually
- Current collection rate 85%, potential for improvement
- Quality challenges: Tramp elements (copper, tin) limiting applications
- Trade dynamics: EU exports scrap to Turkey, Asia; imports high-quality scrap

Research priorities:

- Advanced scrap sorting and characterization technologies
- Removal of tramp elements from scrap
- Design for recyclability in steel-using sectors
- Digital product passports for material tracking
- Life cycle optimization and material efficiency

3.4 Smart Carbon Usage and Breakthrough Technologies

Alternative carbon sources:

- Biomass injection in blast furnaces
- Biochar as partial coke replacement
- Waste-derived reducing agents
- Circular carbon economy concepts

Electrolysis-based routes:

- Molten oxide electrolysis (Boston Metal technology)
- Alkaline electrolysis of iron oxide
- Very early stage, high uncertainty
- Potential for radical disruption if successful

Process optimization and digitalization:

- AI and machine learning for process control
- Digital twins for optimization and training
- Predictive maintenance reducing downtime
- Energy management and demand response
- Quality prediction and defect reduction

4 Coordination Challenges and Member State Dynamics

4.1 Divergent National Priorities

4.1.1 Large Producing States

Germany:

- Climate ambition: 65% reduction by 2030, neutrality 2045
- Hydrogen leadership strategy
- Substantial national co-funding capacity
- Strong influence on EU policy development
- Concern: Energy costs and competitiveness

France:

- Nuclear-powered electricity as decarbonization advantage
- Strategic autonomy and industrial sovereignty emphasis
- ArcelorMittal dominance raising governance questions
- Coordination with Germany on key initiatives

Italy:

- EAF sector already relatively low-carbon
- Taranto integrated mill as major challenge
- PNRR funding deployment challenges
- Seeking EU support for transformation

Spain:

- Multiple smaller integrated and EAF producers
- Regional economic dependencies on steel
- Renewable energy potential for green steel

- Integration with EU-wide initiatives

Poland:

- Coal-dependent economy creating transition challenges
- Large steel sector with employment significance
- EU funding critical for transformation
- Just transition requirements prominent

4.1.2 Smaller Producers and Specialized Cases

Sweden, Finland, Austria:

- High environmental ambitions
- Smaller scale enabling faster transformation
- Renewable energy advantages
- Technology leadership in specific niches

Belgium, Netherlands:

- Port locations with hydrogen import potential
- Integration with industrial clusters
- Coordination challenges with multinational ownership

Eastern European states:

- Development priorities alongside climate goals
- Lower capacity for co-funding
- Dependency on EU structural funds
- Concern about Just Transition support adequacy

4.2 Coordination Mechanisms

4.2.1 EUROFER (European Steel Association)

Role and functions:

- Industry representation to EU institutions
- Policy advocacy and position development
- Coordination of research priorities
- Statistical data and analysis
- Communication on sector transformation

Key positions:

- Support for ambitious climate policy with competitiveness protection
- CBAM as essential to prevent carbon leakage
- Substantial public support needed for transformation
- Skills development and just transition priorities
- Innovation funding continuation post-RFCS

4.2.2 High-Level Steel Platforms

European Steel Technology Platform (ESTEP):

- Strategic research agenda development
- Industry-academia-government dialogue

- Identification of research gaps and priorities
- Input to EU research program design

Regular consultations:

- Commission stakeholder dialogues
- Council working groups
- Parliament committee hearings
- Multi-stakeholder forums on specific issues

4.3 Tensions and Trade-offs

4.3.1 Climate Ambition vs. Industrial Competitiveness

The fundamental dilemma:

- Stricter climate policy increases costs for EU producers
- Global competitors face different regulatory environments
- Risk: Production shifts to regions with lax standards
- Balancing act: Push decarbonization while protecting industry

CBAM as solution attempt:

- Theoretical elegance: Level playing field through border adjustment
- Implementation challenges: Complexity, WTO compatibility
- Effectiveness questions: Export competitiveness not addressed
- Political economy: Developing country resistance

4.3.2 Solidarity vs. Competition Among Member States

Fiscal capacity disparities:

- Large wealthy states (Germany, France) can provide substantial national support
- Smaller/poorer states limited in co-funding capacity
- Risk: Divergence in transformation speed creating internal distortions
- EU funding attempts to compensate but insufficient

State aid control tensions:

- Commission role preventing subsidy races
- Member states seeking flexibility for strategic interventions
- Debate: Strict enforcement vs. pragmatic adaptation
- Response to external competition (US IRA) pressuring liberalization

4.3.3 Speed of Transformation vs. Social Cohesion

Just Transition imperatives:

- Workforce impacts in steel-dependent regions
- Need for retraining, relocation support, early retirement packages
- Regional economic diversification requirements
- Political feasibility constraining optimal pathways

Just Transition Mechanism:

- €17.5 billion envelope (2021-2027)
- Support for carbon-intensive regions
- Includes coal mining areas and industrial sites
- Steel-dependent regions eligible but competing with others

5 International Dimensions and Geopolitical Context

5.1 Trade Relations and Global Competition

5.1.1 China Challenge

Overcapacity and market distortions:

- Chinese steel production >1 billion tonnes vs. 900 million domestic demand
- State subsidies and below-cost exports
- Successive waves of anti-dumping and safeguard measures
- Continued circumvention through third countries

EU responses:

- Anti-dumping duties on numerous Chinese steel products
- Safeguard quotas limiting import surges
- Monitoring system for rapid response
- Bilateral dialogue with limited progress

5.1.2 Transatlantic Relations

US-EU Trade and Technology Council:

- Dialogue on steel and aluminum trade
- Coordination on addressing global overcapacity
- Harmonization of green steel standards
- Technology cooperation on decarbonization

Inflation Reduction Act (IRA) impacts:

- US tax credits creating competitive asymmetry
- EU concern about investment diversion
- Stimulus for EU state aid rule relaxation
- Debate on coordinated vs. competitive subsidies

5.2 Technology Transfer and Development Cooperation

Partnership opportunities:

- EU technology export to developing countries
- Knowledge sharing through international fora (IEA, UNIDO)
- Technical assistance for emerging steel producers
- Balance: Support development while protecting IP and competitiveness

6 Future Outlook

6.1 Scenarios for EU Steel (2025-2050)

6.1.1 Optimistic: Green Leadership

Pathway:

- 2030: 30% emissions reduction achieved through hydrogen pilots and EAF expansion
- 2040: Majority of integrated mills converted to H2-DRI-EAF
- 2050: Near-complete decarbonization, 100-110 MT capacity maintained
- Technology exports generating economic benefits
- CBAM effective in protecting competitiveness

6.1.2 Pessimistic: Managed Decline

Pathway:

- 2030: Insufficient progress, competitiveness deteriorates
- 2040: Major capacity closures, production declining to 70-80 MT
- 2050: Residual specialty production, heavy import dependence
- Technology leadership lost to Asia and Americas
- Social and economic disruption in steel regions

6.1.3 Realistic: Transformation with Capacity Adjustment

Pathway:

- 2030: 25% emissions reduction, major projects underway
- 2040: 60-70% capacity decarbonized, production 90-100 MT
- 2050: Carbon neutrality achieved with some import dependence
- Specialization in high-value segments
- Managed social transitions with EU support

6.2 Critical Success Factors

Policy coherence and stability:

- Sustained commitment across political cycles
- Coordination between EU and national levels
- Integration of climate, industrial, trade, social policies

Adequate financial support:

- Scaling Innovation Fund and related mechanisms
- Member state co-funding where needed
- Private sector investment mobilization
- Carbon pricing revenues recycled to support transition

Effective competitiveness protection:

- CBAM implementation without major disruptions
- Trade policy addressing unfair competition
- Coordination with international partners
- Export support complementing import protection

Technology development and deployment:

- Continued innovation funding
- Rapid scale-up from pilot to commercial
- Knowledge sharing and best practice diffusion
- Breakthrough technologies reaching market

Social acceptance and just transition:

- Worker retraining and support
- Regional economic diversification
- Public communication on necessity and benefits
- Inclusive stakeholder engagement

7 Conclusions

The European Union's steel decarbonization represents an unprecedented experiment in coordinating industrial transformation across diverse national contexts within supranational policy frameworks. Success requires balancing multiple objectives: climate leadership, industrial competitiveness, social cohesion, and geopolitical security.

Key strengths:

- Comprehensive policy architecture
- Substantial financial resources
- Technology leadership in key areas
- Political commitment to climate goals

Critical challenges:

- Coordination complexity across 27 member states
- Competitiveness pressures from global competition
- Social and regional impacts requiring management
- Technology and hydrogen supply uncertainties

The coming decade will determine whether Europe successfully transforms its steel industry or experiences industrial decline. The outcome has implications extending far beyond steel, serving as a test case for European industrial policy in the 21st century.

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