Odisha: India's Emerging Steel Powerhouse and Decarbonization Leader

MIFUS Course - Steel Decarbonization Policies Worldwide
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November 22, 2025

Abstract

Odisha has emerged as India's leading steel-producing state, accounting for over 20% of national production with approximately 26-27 million tonnes annually. With ambitious plans to reach 100 million tonnes capacity by 2030, the state faces both unprecedented growth opportunities and critical decarbonization challenges. This document examines Odisha's steel sector landscape, natural resource advantages, major industrial players, state-level policies, and pathways toward sustainable steel production.

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1 Introduction to Odisha's Steel Sector

1.1 Geographic and Economic Context

Odisha, located on India's eastern coast, has transformed from an agriculture-dominated economy to India's premier steel manufacturing hub:

- **Capital:** Bhubaneswar
- **Major Industrial Centers:** Jajpur, Angul, Sundargarh, Jharsuguda, Dhenkanal
- **Coastal Access:** Paradip Port (major steel export gateway)
- **Population:** Approximately 46 million (2021)
- **Steel's Economic Impact:** Significant contributor to state GDP and employment

1.2 Production Statistics

Metric	Value (FY 2023-24)
Crude Steel Production	26-27 million tonnes
Share of National Production	20.5%
Installed Capacity	32.45 million tonnes
Number of Steel Plants	47
Capacity Utilization	Approximately 80-83%
Major Technology Routes	BF-BOF, DRI-EAF
Target Capacity (2030)	100 million tonnes

Table 1: Odisha Steel Sector Overview

1.3 Growth Trajectory

Odisha's steel sector has experienced remarkable expansion:

- **Historical Growth:** From negligible production in 1990s to national leader
- **Investment Pipeline:** Over 5 lakh crore (approximately $60 billion) committed
- **2030 Vision:** Quadruple current production to 100 MT
- **Employment:** Over 500,000 direct and indirect jobs in steel sector
- **Ancillary Industries:** Extensive ecosystem of downstream steel processors

2 Natural Resource Endowment

Odisha's dominance in steel production stems from extraordinary natural resource wealth:

2.1 Iron Ore Resources

Reserves:

- **Total Reserves:** Approximately 5.5 billion tonnes (about 33% of India's total)
- **Quality:** High-grade hematite (Fe content 60-68%)
- **Major Deposits:** Barbil-Koira, Bonai, Tomka-Daitari, Barsua, Bolani
- **Mining Districts:** Keonjhar, Sundargarh, Mayurbhanj

Production Capacity:

- Annual iron ore production: 120-140 million tonnes
- Largest iron ore producing state in India
- Supplies both domestic steel plants and exports
- Multiple operational mechanized mines

2.2 Coal Resources

- **Coalfields:** Talcher, Ib River, Rampur
- **Reserves:** Significant thermal and coking coal deposits
- **Mahanadi Coalfields Limited (MCL):** Major producer supplying steel plants
- **Coal Production:** Over 150 million tonnes annually (state total)
- **Captive Coal:** Many steel plants have captive coal blocks

2.3 Other Minerals

- **Chromite:** 98% of India's reserves (Sukinda valley)
- **Manganese:** Significant deposits for steel alloying
- **Dolomite:** Essential for steel production (flux material)
- **Limestone:** Abundant reserves for flux and cement
- **Bauxite:** Large reserves supporting aluminum industry

2.4 Water Resources

- **Major Rivers:** Mahanadi, Brahmani, Baitarani
- **Reservoirs:** Hirakud Dam and multiple medium dams
- **Industrial Water Supply:** Generally adequate but with seasonal constraints
- **Water Management:** Increasingly critical for sustainable steel production

2.5 Renewable Energy Potential

- **Solar Potential:** Approximately 26 GW
- **Wind Potential:** Limited compared to southern/western states
- **Hydropower:** Some existing capacity, limited expansion potential
- **Biomass:** Agricultural and forest residues available
- **Coastal Location:** Potential for offshore wind development

3 Major Steel Producers

3.1 Tata Steel Odisha

Locations: Kalinganagar (Jajpur district), Gopalpur

Capacity and Production:

- Current Capacity: 8.3 MTPA (Phase II operational)
- Planned Expansion: Up to 18 MTPA in phases
- Technology: Integrated BF-BOF complex
- Investment: Over 60,000 crore committed

Decarbonization Initiatives:

- Renewable energy integration targets
- Green hydrogen feasibility studies
- Energy efficiency improvements through digitalization
- Waste heat recovery systems
- Water recycling: 98% water recirculation
- Carbon footprint reduction roadmap aligned with global Tata Steel targets

Strategic Importance:

- One of India's most modern integrated steel plants
- Greenfield development with advanced technology
- Export-oriented production (coastal location advantage)
- Benchmark for environmental compliance

3.2 JSW Steel Odisha

Location: Jajpur and Angul districts

Capacity and Production:

- Multiple facilities totaling approximately 5-6 MTPA
- Expansion plans: Additional 13.2 MTPA planned
- Technology mix: DRI-EAF and pellet production
- Iron ore slurry pipeline: Efficient raw material transport

Sustainability Features:

- Captive power plants with renewable energy targets
- Advanced pollution control equipment
- Zero liquid discharge systems
- ResponsibleSteel certification pursuit
- Green steel production pathway development

3.3 ArcelorMittal Nippon Steel (AMNS India)

Location: Paradeep (Jagatsinghpur district)

Facility Details:

- Capacity: 9 MTPA
- Technology: Integrated steel plant with pellet complex
- Port connectivity: Direct access to Paradip Port
- Expansion plans: Potential to increase capacity

Environmental Approach:

- State-of-the-art environmental management
- Global technology standards (ArcelorMittal and Nippon Steel heritage)
- Focus on circular economy principles
- Community development programs

3.4 SAIL - Rourkela Steel Plant (RSP)

Location: Rourkela (Sundargarh district)

Historical Significance:

- Established: 1959 (first integrated steel plant with German collaboration)
- Current Capacity: 2 MTPA (post-modernization)
- Technology: BF-BOF with continuous upgrades
- Legacy: Training ground for Indian steel industry professionals

Modernization and Sustainability:

- Recent modernization: 12,000+ crore investment
- Energy efficiency improvements
- Emission reduction through technology upgrades
- Heritage plant transitioning to modern environmental standards
- Challenges: Retrofitting older infrastructure

3.5 Jindal Steel and Power Limited (JSPL)

Location: Angul district

Operations:

- Capacity: Approximately 6 MTPA
- Technology: DRI-based production
- Captive iron ore and coal mines
- Pellet manufacturing facilities

Strategic Focus:

- Value-added steel products
- Vertical integration
- Export market development
- Renewable energy adoption initiatives

3.6 Other Significant Players

- **Bhushan Power & Steel Limited (Odisha Unit)**
- **Essar Steel India Limited (Acquired facility)**
- **Shyam Steel Industries**
- **Nilachal Ispat Nigam Limited (NINL):** Government-promoted plant
- **Various Medium and Small Steel Plants:** Induction furnaces and rolling mills

4 State Government Policies and Initiatives

4.1 Odisha Industrial Policy Framework

4.1.1 Industrial Policy Resolution (Latest Edition)

Key provisions for steel sector:

- Priority sector status for steel and downstream industries
- Fiscal incentives including tax holidays and subsidies
- Single-window clearance system
- Land acquisition facilitation
- Infrastructure development commitments
- Skill development programs

4.1.2 Steel Policy Initiatives

Vision 100 by 2030:

- Target: 100 million tonnes steel capacity by 2030
- Current to target: Nearly 4x growth required
- Policy measures: Investor-friendly regulatory environment
- Infrastructure: Industrial corridors and logistics parks

Downstream Industry Promotion:

- Value addition emphasis
- Steel fabrication and processing units
- Industrial parks for steel-using industries
- Automotive and engineering clusters

4.2 Environmental and Sustainability Policies

4.2.1 State Action Plan on Climate Change (SAPCC)

- Industrial emissions reduction targets
- Energy efficiency mandates for large industries
- Renewable energy integration requirements
- Afforestation and compensatory forestry
- Water conservation in industrial sectors

4.2.2 Odisha Renewable Energy Policy

- Target renewable energy capacity additions
- Incentives for industrial captive renewable projects
- Waiver of transmission charges for renewable power (under consideration)
- Solar park development
- Wind energy potential assessment and promotion

4.2.3 Environmental Compliance Framework

- **State Pollution Control Board (SPCB):** Strict monitoring
- **Emission Standards:** Alignment with national norms
- **Online Continuous Emission Monitoring Systems (CEMS):** Mandatory for steel plants
- **Air Quality Management:** Special focus in industrial clusters
- **Water Pollution Control:** Zero Liquid Discharge (ZLD) requirements

4.3 Resource Governance and Sustainability

4.3.1 Mining Policy Reforms

- Transparent auction process for mining leases
- District Mineral Foundation (DMF): Community benefit sharing
- Sustainable mining practices mandatory
- Mine closure and reclamation plans
- Environmental clearance stringency

4.3.2 Rehabilitation and Resettlement

- Comprehensive R&R policies for project-affected populations
- Employment guarantees in new industrial projects
- Community development obligations for companies
- Forest Rights Act (FRA) compliance requirements

4.4 Infrastructure Development Initiatives

4.4.1 Industrial Corridors

- **Paradip-Haldia Industrial Corridor:** Connecting steel plants to port
- **Angul-Talcher Industrial Complex:** Integrated steel and power hub
- **Rail Connectivity:** Dedicated freight corridors
- **Road Networks:** NH and state highway upgrades

4.4.2 Port Infrastructure

- **Paradip Port:** Capacity expansion for steel exports
- **Gopalpur Port:** Private port serving steel industry
- **Dhamra Port:** Additional coastal gateway
- **Integrated logistics:** Port-plant connectivity improvements

4.4.3 Power Infrastructure

- Adequate coal-based power generation capacity
- Grid strengthening for industrial loads
- Renewable energy evacuation infrastructure
- Dedicated power supply to industrial areas

4.5 Skill Development and Employment

- State-sponsored ITIs and skill training centers
- Partnerships with steel companies for apprenticeship programs
- Technical education institutions: NIT Rourkela, other engineering colleges
- Employment exchanges and job fairs
- Local employment quotas in industrial projects

5 Decarbonization Challenges and Opportunities

5.1 Current Emission Profile

Estimated Annual Emissions:

- Total CO_2 from steel sector: Approximately 50-60 million tonnes (2023)
- State's share of national steel emissions: 20-25%
- Emission intensity: Varies by plant and technology (2.2-2.8 tonnes CO_2/tonne steel)

- Growth trajectory: Emissions expected to rise with capacity expansion

Sources of Emissions:

- Blast furnace operations (largest source)
- Coal-based DRI plants
- Captive power plants (coal-fired)
- Transportation and logistics
- Pellet manufacturing

5.2 State-Specific Challenges

5.2.1 Rapid Growth vs. Decarbonization

- Ambition to reach 100 MT capacity creates emission growth risk
- New capacity mostly planned as conventional technology (BF-BOF)
- Investment decisions being made now will lock in emissions for 40-50 years
- Pressure to maintain competitiveness and cost efficiency
- Limited awareness of carbon costs in long-term planning

5.2.2 Technology Lock-in

- Large existing BF-BOF capacity with decades of remaining life
- High capital cost of premature retirement or conversion
- Limited proven retrofit options for deep decarbonization
- DRI plants predominantly coal-based (abundant coal locally)
- Infrastructure optimized for fossil fuel-based production

5.2.3 Renewable Energy Constraints

- Lower solar and wind potential compared to western/southern India
- Monsoon season affects solar generation
- Limited land availability for large-scale renewable projects
- Grid infrastructure needs upgrades for high renewable penetration
- Competition for renewable resources with other sectors

5.2.4 Water Stress

- Industrial water demand competing with agriculture and domestic needs
- Seasonal water scarcity in some districts
- Green hydrogen production would significantly increase water demand
- Requirement for advanced water recycling and desalination

5.2.5 Social and Environmental Trade-offs

- Mining expansion vs. forest conservation
- Indigenous communities' rights and displacement concerns
- Air quality degradation in industrial clusters
- Biodiversity impacts in mineral-rich areas
- Balancing development with environmental protection

5.3 Opportunities and Advantages

5.3.1 Resource Availability

- **Iron Ore:** Abundant high-quality reserves reduce import dependency
- **Coal Resources:** Transition fuel availability for interim period
- **Limestone and Dolomite:** Essential inputs readily available
- **Reduced Transportation Emissions:** Integrated value chain

5.3.2 New Capacity as Green Capacity

- Greenfield projects can adopt latest low-carbon technologies
- Opportunity to leapfrog to hydrogen-ready infrastructure
- EAF capacity expansion can use renewable electricity
- DRI plants can be designed for natural gas/hydrogen flexibility
- Setting new benchmarks for efficiency in India

5.3.3 Port-Based Advantage

- Access to international green steel markets
- Potential for green hydrogen imports if needed
- Lower logistics costs for exports
- Proximity to Southeast Asian markets
- Early mover advantage in green steel exports

5.3.4 Strong Industrial Base

- Concentration of major steel producers enables cluster approach
- Shared infrastructure potential (hydrogen pipelines, CO_2 transport)
- Knowledge sharing and technology demonstration
- Economies of scale for green technology deployment
- Established supply chains and skilled workforce

5.3.5 Government Commitment

- State government recognizes steel as priority sector
- Willingness to provide policy support for sustainable growth
- Infrastructure investment commitments
- Potential for state-level green steel incentives
- Collaboration with industry on sustainability roadmaps

6 Decarbonization Pathways for Odisha

6.1 Near-Term Actions (2025-2030)

6.1.1 Energy Efficiency Improvements

Current Status: Most plants operate below international best practice

Opportunities:

- Pulverized Coal Injection (PCI) optimization in blast furnaces
- Top gas recovery systems
- Waste heat recovery for power generation
- Advanced process control and automation
- Predictive maintenance reducing downtime

Potential Impact: 5-10% emission reduction

6.1.2 Renewable Energy Integration

Immediate Actions:

- Rooftop solar on plant buildings
- Captive solar parks on available land
- Open access renewable power purchase agreements
- Hybrid wind-solar projects in suitable locations

- Battery storage for load management

State Policy Support Needed:

- Waiver of open access charges for green power
- Banking facilities for variable renewable generation
- Facilitation of land for renewable projects
- Simplified approvals for captive renewable plants

Potential Impact: 15-20% emission reduction from power supply

6.1.3 Scrap-Based Steel Expansion

Current Constraint: Limited scrap availability in Odisha
Development Strategy:

- Establish organized scrap collection networks
- Metal scrapping centers in major cities
- Ship-breaking scrap from coastal areas
- Import infrastructure at ports for international scrap
- Small-scale EAF and induction furnace modernization

Target: Increase EAF share from ¡10% to 15-20% by 2030

6.1.4 Natural Gas Transition

Infrastructure Development:

- Jagdishpur-Haldia-Bokaro-Dhamra (JHBDPL) pipeline connectivity
- LNG terminal access via Dhamra Port
- Conversion of DRI plants to natural gas capability
- Gas-based DRI as bridge to hydrogen

Challenges: Natural gas cost competitiveness vs. coal

6.2 Medium-Term Actions (2030-2045)

6.2.1 Green Hydrogen Deployment

Pilot Phase (2030-2035):

- Demonstration projects at 1-2 major plants
- Hydrogen blending in existing DRI plants (up to 30%)
- Electrolyzer installations near renewable energy sources

- Hydrogen storage and distribution infrastructure development
- Technology learning and cost reduction

Scale-up Phase (2035-2045):

- Commercial H2-DRI-EAF plants for new capacity
- Conversion of coal-based DRI to hydrogen
- Dedicated renewable energy parks for hydrogen production
- Potential offshore wind for coastal electrolysis
- State-wide hydrogen pipeline network

Requirements:

- Green hydrogen cost: Reduction to ¡$2/kg
- Renewable capacity: 3-4 GW dedicated to steel sector
- Water supply: Desalination infrastructure for coastal plants
- Investment: $15-20 billion for hydrogen infrastructure

6.2.2 CCUS Implementation

Suitability Assessment:

- Geological storage potential: Coastal sedimentary basins
- Proximity to existing oil and gas fields (limited in Odisha)
- CO_2 utilization opportunities: Enhanced oil recovery, mineralization
- Potential for cluster approach given steel plant concentration

Development Pathway:

- Detailed geological surveys for CO_2 storage sites
- Pilot CCUS projects at 1-2 large integrated plants
- CO_2 pipeline infrastructure planning
- Technology selection and adaptation to Indian conditions
- Cost reduction through learning and scale

Challenges:

- High current cost ($50-60/tonne CO_2)
- Limited storage characterization
- Regulatory framework for CO_2 transport and storage
- Public acceptance and safety concerns

6.2.3 Advanced Steel Production Technologies

- Smelting reduction processes (e.g., HIsmelt, if hydrogen-enabled)
- Direct electrolysis of iron ore (long-term R&D)
- Biomass integration in ironmaking
- Molten oxide electrolysis
- Emerging technologies adapted for Indian conditions

6.3 Long-Term Vision (2045-2070)

6.3.1 Near-Zero Emission Steel Production

Technology Mix by 2070:

- 40-50%: Green hydrogen-based DRI-EAF
- 30-35%: Scrap-based EAF with renewable electricity
- 15-20%: BF-BOF with full CCUS (if economically viable)
- 5-10%: Novel technologies (direct electrolysis, etc.)

Supporting Infrastructure:

- 100% renewable electricity supply to steel sector
- Comprehensive hydrogen production and distribution network
- Mature scrap collection and processing ecosystem
- CO_2 transport and storage infrastructure (if CCUS deployed)
- Circular economy integration across value chain

Odisha's Target: Net-zero steel production aligned with national 2070 goal

7 Investment and Financing

7.1 Investment Requirements

Total Estimated Investment for Decarbonization (2025-2070):

- Capacity expansion to 100 MT: $40-50 billion
- Additional decarbonization investment: $30-40 billion
- Renewable energy infrastructure: $10-15 billion
- Hydrogen production and distribution: $12-18 billion
- CCUS infrastructure (if deployed): $8-12 billion
- **Total: $100-135 billion over 45 years**

7.2 Financing Sources and Mechanisms

7.2.1 Corporate Investment

- Internal accruals from profitable operations
- Debt financing from domestic and international banks
- Green bonds and sustainability-linked bonds
- Private equity and infrastructure funds
- Strategic partnerships and joint ventures

7.2.2 Government Support

Central Government:

- PLI schemes for specialty and green steel
- National Green Hydrogen Mission support
- Technology demonstration grants
- Concessional financing through development banks
- Tax incentives for green investments

State Government:

- Capital subsidies for green technology adoption
- Interest subvention on green project loans
- Land provision at concessional rates
- Infrastructure co-investment (roads, power, water)
- Fiscal incentives (tax holidays, duty exemptions)

7.2.3 International Climate Finance

- Green Climate Fund (GCF) resources
- World Bank and ADB green lending
- Bilateral development cooperation (EU, Japan, Germany)
- Technology transfer agreements with developed countries
- Carbon credit mechanisms (if developed)

7.2.4 Innovative Financing Mechanisms

- Transition finance for gradual decarbonization
- Blended finance structures (public-private)
- Green steel offtake agreements providing revenue certainty
- Performance-based incentives tied to emission reductions
- Securitization of future carbon savings

7.3 Financial Challenges

- High upfront capital costs of green technologies
- Long payback periods (20-30 years)
- Uncertainty about future carbon prices and green premiums
- Currency risk for international financing
- Technology risk for unproven solutions
- Competition for capital with other priorities

8 Social and Environmental Considerations

8.1 Employment Transition

Job Creation:

- New steel capacity: 200,000+ direct jobs expected by 2030
- Renewable energy sector: 50,000+ jobs in construction and O&M
- Hydrogen economy: Emerging employment in production, distribution
- Downstream industries: Value-added steel processing employment
- Scrap collection and recycling: Formalization creating quality jobs

Job Transition Challenges:

- Coal mining employment may decline with reduced coal use
- Skills mismatch: Need retraining for green technologies
- Automation reducing labor intensity in modern plants
- Temporary displacement during plant retrofits

Just Transition Strategy:

- Skill development programs for renewable energy and hydrogen technologies

- Retraining programs for workers in declining sectors
- Social protection measures during transition
- Entrepreneurship support in green economy
- Involvement of local communities in new projects

8.2 Air Quality and Health

Current Challenges:

- Industrial clusters with elevated PM2.5 and PM10 levels
- Respiratory health impacts in communities near steel plants
- Fugitive emissions from material handling and storage
- Pollution from captive power plants

Decarbonization Co-Benefits:

- Reduced coal combustion → lower particulate emissions
- Green hydrogen eliminates combustion pollutants
- Renewable electricity reduces thermal power plant emissions
- Modern technology with better pollution controls
- Improved local air quality and public health outcomes

8.3 Water Management

Water Demand Projections:

- Current steel sector water use: 150 million m^3/year
- Projected 2030 demand (100 MT capacity): 500 million m^3/year
- Green hydrogen additional demand: 50-100 million m^3/year

Sustainable Water Strategies:

- Zero Liquid Discharge (ZLD) mandatory for all plants
- Water recycling targets: 95-98% recirculation
- Desalination for coastal plants (using renewable energy)
- Rainwater harvesting at industrial complexes
- Watershed management and groundwater recharge programs
- Treated municipal wastewater reuse

8.4 Biodiversity and Land Use

Concerns:

- Forest land diversion for mining and industrial projects
- Habitat fragmentation affecting wildlife corridors
- Impacts on elephant migration routes
- Mining in ecologically sensitive areas

Mitigation Measures:

- Compensatory afforestation (twice the diverted forest area)
- Green belts around industrial areas
- Wildlife corridors preservation
- Biodiversity offset programs
- Restoration of degraded mining areas
- Strict adherence to coastal regulation zones

8.5 Community Engagement

Stakeholder Participation:

- Public hearings for environmental clearances
- Corporate Social Responsibility (CSR) programs
- District Mineral Foundation (DMF) funded community projects
- Gram Sabha consent for forest land diversion (PESA Act)
- Grievance redressal mechanisms

Benefit Sharing:

- Local employment quotas (typically 70-80% for unskilled jobs)
- Infrastructure development (schools, hospitals, roads)
- Livelihood programs for project-affected families
- Education and healthcare support
- Skill training for local youth

9 Research, Development, and Innovation

9.1 Academic and Research Institutions

Key Institutions in Odisha:

- **National Institute of Technology (NIT) Rourkela:** Metallurgical and materials engineering research
- **CSIR-Institute of Minerals and Materials Technology (IMMT), Bhubaneswar:** Mineral processing and extractive metallurgy
- **Indian Institute of Technology (IIT) Bhubaneswar:** Emerging research in sustainable materials
- **Regional Research Laboratory:** Industrial applications research
- **Various State Universities:** Supporting research programs

9.2 Industry-Academia Collaboration

- Joint research projects on low-carbon steelmaking
- Sponsored research chairs in steel companies
- Student internships and industry training
- Technology demonstration at academic institutions
- Knowledge transfer workshops and conferences

9.3 Priority Research Areas

- **Green Hydrogen Integration:** H2-DRI process optimization for Indian conditions
- **Low-Grade Ore Utilization:** Beneficiation and agglomeration technologies
- **Carbon Capture and Utilization:** Mineralization of CO_2 in steel slag
- **Waste Heat Recovery:** Advanced systems for energy efficiency
- **Alternative Reductants:** Biomass and biochar in blast furnaces
- **Circular Economy:** Steel slag utilization in construction and agriculture
- **Process Modeling:** AI/ML for process optimization and emission reduction
- **Water Treatment:** Advanced technologies for ZLD systems

9.4 Innovation Ecosystem

Needs:

- State-level innovation fund for green steel technologies
- Technology incubation centers
- Pilot plant facilities for technology demonstration
- Intellectual property support for researchers
- International collaboration platforms
- Start-up ecosystem for cleantech solutions

10 Regional and International Context

10.1 Competitive Position

Advantages:

- Lowest production costs in India due to integrated value chain
- Proximity to raw materials reduces logistics costs
- Port access enables competitive exports
- Large domestic market in eastern India
- Government support and stable policy environment

Challenges:

- Competition from other Indian states (Jharkhand, Chhattisgarh)
- Global overcapacity affecting prices
- Rising environmental compliance costs
- Import competition from China, South Korea, Japan
- Need to maintain cost competitiveness during green transition

10.2 Export Markets

Current Exports:

- Primary Markets: Middle East, Southeast Asia, Africa
- Products: Billets, slabs, finished steel products
- Export Volume: 3-4 million tonnes annually from Odisha
- Port of Loading: Paradip, Gopalpur, Dhamra

Green Steel Export Potential:

- EU market with CBAM: High-value opportunity if emission intensity reduced
- ResponsibleSteel certification opens premium markets
- First-mover advantage in South Asian green steel
- Potential green premium: 5-15% above conventional steel
- Export competitiveness depends on decarbonization progress

10.3 Regional Cooperation

Eastern India Steel Cluster:

- Coordination with Jharkhand and Chhattisgarh
- Shared infrastructure development (hydrogen pipelines, CO_2 transport)
- Joint R&D initiatives
- Common sustainability standards
- Regional supply chain optimization

International Partnerships:

- Technology collaboration with Japan, Germany, South Korea
- Investment from global steel companies (ArcelorMittal, Nippon Steel)
- Knowledge exchange programs
- Participation in global steel sustainability initiatives

11 Monitoring and Reporting Framework

11.1 Emissions Measurement and Reporting

Current Practice:

- Continuous Emission Monitoring Systems (CEMS) for criteria pollutants
- Annual environmental statements to SPCB
- Energy audits under PAT scheme
- GHG reporting under voluntary frameworks

Enhanced Requirements:

- Standardized carbon accounting methodology (Scope 1, 2, 3)
- Plant-level emission intensity reporting

- Product-level carbon footprinting
- Third-party verification of emissions data
- Real-time emission data availability
- Integration with national emissions database

11.2 Progress Tracking Indicators

Production Metrics:

- Total crude steel production (million tonnes)
- Production by technology route (BF-BOF, DRI-EAF, scrap-EAF)
- Capacity utilization rates
- Product mix (long steel, flat steel, specialty)

Environmental Metrics:

- Emission intensity (tonnes CO_2/tonne steel)
- Total annual GHG emissions (million tonnes CO_2e)
- Energy intensity (GJ/tonne steel)
- Renewable energy share (%)
- Water intensity (m^3/tonne steel)
- Waste recycling rate (%)

Technology Metrics:

- Green hydrogen production capacity (tonnes/year)
- EAF capacity share (%)
- Scrap consumption (million tonnes)
- CCUS capacity installed (tonnes CO_2/year)
- Renewable energy capacity (MW)

Socio-Economic Metrics:

- Direct employment in steel sector
- Investment in decarbonization (crore)
- CSR expenditure on community development
- Local procurement value (%)
- Safety performance indicators

11.3 Transparency and Disclosure

- Annual sustainability reports by major producers
- State-level steel sector sustainability dashboard
- Public access to emission data
- Stakeholder engagement and feedback mechanisms
- Alignment with CDP, TCFD reporting frameworks
- Integration with ResponsibleSteel certification process

12 Roadmap and Recommendations

12.1 Immediate Priorities (2025-2027)

1. **Baseline Assessment:**
    - Comprehensive GHG inventory of all steel plants
    - Technology audit and efficiency benchmarking
    - Resource mapping (renewable energy, water, scrap)
    - Infrastructure gap analysis
2. **Policy Formulation:**
    - Odisha Green Steel Policy and Action Plan
    - Renewable energy mandates for steel sector
    - Green steel procurement guidelines for state projects
    - Streamlined approvals for decarbonization projects
3. **Quick Wins:**
    - Energy efficiency programs (waste heat recovery, process optimization)
    - Rooftop solar installations at existing plants
    - Open access renewable power agreements
    - Water recycling system upgrades
4. **Capacity Building:**
    - Training programs on carbon accounting and management
    - Awareness campaigns on green steel technologies
    - Academic curriculum updates
    - International study tours and knowledge exchange

12.2 Medium-Term Roadmap (2028-2035)

1. **Infrastructure Development:**
    - Renewable energy parks (2-3 GW) dedicated to steel sector
    - Natural gas pipeline connectivity to all major plants
    - Enhanced scrap collection and processing infrastructure
    - Hydrogen pilot production facilities
2. **Technology Demonstration:**
    - Green hydrogen-based DRI pilot plant
    - CCUS demonstration at 1-2 integrated plants
    - Advanced EAF with 100% renewable power
    - Biomass co-firing in blast furnaces
3. **Market Development:**
    - Green steel certification and labeling
    - Premium pricing mechanisms
    - Export promotion of low-carbon steel
    - Customer engagement programs
4. **Financing Mechanisms:**
    - State green steel fund establishment
    - Blended finance structures
    - International climate finance mobilization
    - Green bond issuance support

12.3 Long-Term Vision (2036-2070)

1. **Technology Transformation:**
    - Majority of new capacity as green hydrogen-based or EAF
    - Existing plants retrofitted with CCUS or converted
    - Near-zero emission steel production achieved
    - Integration of novel technologies (direct electrolysis)
2. **Circular Economy:**
    - Maximize scrap-based steel production (30-40% of total)
    - Complete waste valorization (slag, dust, sludge)
    - Closed-loop water systems across all plants
    - Symbiotic relationships with other industries
3. **Regional Leadership:**

- Odisha as India's green steel hub
- Technology export and knowledge transfer to other regions
- Center of excellence for sustainable steel production
- Model for resource-rich regions globally

12.4 Key Recommendations

For State Government:

- Develop comprehensive Odisha Green Steel Policy with clear targets
- Provide fiscal incentives for green technology adoption
- Invest in enabling infrastructure (renewable energy, hydrogen)
- Mandate green steel in public procurement
- Establish monitoring and enforcement mechanisms
- Create innovation fund for R&D
- Ensure just transition for affected workers and communities

For Steel Industry:

- Commit to science-based emission reduction targets
- Invest in pilot and demonstration projects
- Collaborate on shared infrastructure (hydrogen, CO_2 transport)
- Enhance transparency through regular reporting
- Engage with supply chain on Scope 3 emissions
- Participate in global green steel initiatives
- Support workforce training and development

For Financial Institutions:

- Develop green steel financing products
- Provide concessional rates for decarbonization projects
- Build expertise in evaluating green steel technologies
- Support transition finance for gradual decarbonization
- Engage with international climate finance sources

For Academia and Research:

- Focus research on India-specific decarbonization challenges
- Establish pilot facilities for technology demonstration
- Strengthen industry-academia linkages
- Train next generation of green steel professionals
- Contribute to policy analysis and recommendations

13 Conclusion

Odisha stands at a pivotal moment in its steel sector development. The state's ambition to become a 100 million tonne steel producer by 2030 presents both an enormous opportunity and a profound responsibility. With the right policies, investments, and technologies, Odisha can achieve this growth while simultaneously becoming India's leader in green steel production.

The state's abundant natural resources—iron ore, coal, renewable energy potential—provide a strong foundation. The presence of major global steel producers brings world-class technology and management expertise. The state government's commitment to industrial development creates a supportive policy environment.

However, the challenges are significant: the need to transition from coal-dependent production to low-carbon pathways, the high costs of new technologies, the complexity of building new infrastructure, and the imperative to ensure a just transition for workers and communities.

Success will require:

- **Vision and Leadership:** Bold targets backed by concrete action plans
- **Investment:** Mobilization of $100+ billion over coming decades
- **Innovation:** Rapid development and deployment of green technologies
- **Collaboration:** Partnership among government, industry, finance, academia
- **Patience and Persistence:** Recognition that deep decarbonization takes decades

Odisha has the potential to demonstrate that rapid industrial growth and environmental sustainability are not mutually exclusive. By embracing the green steel transition, the state can secure its economic future, protect its environment, support its communities, and contribute meaningfully to India's and the world's climate goals.

The journey toward net-zero steel by 2070 begins now, with every plant efficiency improvement, every renewable energy contract, every technology pilot, and every policy decision. Odisha's actions will shape not only the state's future but also provide a model for steel decarbonization in resource-rich regions across the developing world.

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