

# STEEL DECARBONISATION POLICIES

**China is Running Fast,  
Will Europe Run as a Team as Fast?**

*The MIFUS Course:  
A Global Journey Through Steel Decarbonization*

## **Course Presentation Speech**

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# 1 Opening: The Steel Challenge of Our Time

## 1.1 The Opening Statement [2-3 minutes]

*[Begin with direct engagement]*

Good morning/afternoon, colleagues and students. Today we embark on what I call a **journey**—not just through slides and statistics, but through one of the most consequential industrial transformations in human history.

The steel industry. **1.9 billion tonnes per year. 7-9% of global CO emissions.** An industry that literally built our modern world—from the bridges we cross, to the cars we drive, to the buildings that shelter us.

But here's the uncomfortable truth: *the way we make steel today is fundamentally incompatible with a livable climate future.*

### THE CENTRAL QUESTION

Can we decarbonize steel production without destroying the industry that underpins modern civilization?

And more specifically: **Can Europe compete with China in this race?**

## 1.2 Why This Course Exists: The MIFUS Project

This course—which I've titled **MIFUS: A Global Journey Through Steel Decarbonization**—is not a traditional metallurgy course. Yes, we'll talk about blast furnaces, direct reduced iron, and electric arc furnaces. But more importantly, we'll explore:

- **Geopolitics:** Why is China moving so decisively while Europe hesitates?
- **Economics:** Can green steel survive without subsidies?
- **Technology:** Which pathways will win—hydrogen, electrification, or carbon capture?
- **Policy:** Are carbon border adjustments enough to protect European industry?
- **Society:** What happens to 2.8 million steel workers globally if we get this wrong?

MIFUS stands for multiple things:

- *Metallurgy In Flux Under Stress*
- *Materials Innovation For Urgent Sustainability*
- But most importantly: ***Making Industrial Futures Under unStable conditions***

Because that's exactly where we are—making crucial decisions about industrial futures while everything around us is unstable: energy prices, geopolitics, technology maturity, climate urgency.

### 1.3 The Journey Metaphor

I call this a *journey* deliberately. In MIFUS, we will travel:

1. **From West to East:** Starting in Germany and Austria (the focus of today's presentation), then moving through Sweden, France, Italy, Poland, eventually reaching China, India, Japan, Korea.
2. **From Present to Future:** Understanding what's happening *right now* in 2024-2025, then projecting scenarios to 2030, 2035, and 2050.
3. **From Technology to Reality:** Starting with pure engineering (how do you actually make steel with hydrogen?) and ending with hard economic and political realities (why did ArcelorMittal withdraw from German subsidies?).

Each country we "visit" in MIFUS tells a different story. Each has made different bets. And critically: **not all of them will succeed.**

## 2 The Race: China vs Europe

### 2.1 Why "China Running Fast" Matters [5 minutes]

Let me be blunt: **China has changed the game, and most of Europe hasn't noticed yet.**

In October 2024, China announced a series of steel policies that fundamentally altered global decarbonization dynamics. Let me give you the numbers:

#### CHINA'S OCTOBER 2024 STEEL REVOLUTION

##### Production Scale:

- 1,015 Mt crude steel in 2024 (53% of global output)
- More than EU + USA + Japan + India *combined*

##### Policy Shifts:

- **Zero new blast furnace approvals** in H1 2024—unprecedented
- **EAF expansion:** 10% → 15% share by 2025 (only EAF projects approved)
- **Scrap mobilization:** 214 Mt → 300 Mt/year (+40% in 18 months)
- **Emissions reduction:** -53 Mt CO in 2024-2025 alone
- **Carbon trading:** Steel sector fully integrated into national ETS

**Timeline:** All major actions implemented *within 12 months*

#### 2.1.1 What This Means for Europe

China didn't choose the same path as Europe. While Germany bets €12.5 billion on hydrogen-based direct reduction, China chose:

1. **Pragmatic scrap-EAF expansion** (proven technology, immediate deployment)
2. **Massive scrap collection infrastructure** (300 Mt/year by 2025)
3. **Selective hydrogen pilots** (testing, not betting the farm)
4. **Fast implementation** (policy to action in months, not years)

The **strategic divergence** is profound:

European Approach	Chinese Approach
Premium technology (H-DRI)	Pragmatic technology (EAF+scrap)
High risk, high reward	Lower risk, proven path
Expensive (\$800-1,000/t target)	Affordable (\$300-400/t target)
Slow (2027-2030 timelines)	Fast (2024-2025 implementation)
Subsidy-dependent	Market-driven
Export-focused	Domestic-focused

**The uncomfortable question:** What if China's pragmatic approach achieves 60-70% decarbonization at \$300/tonne while Europe's premium approach struggles to reach 80-90% at \$800/tonne?

Who wins that competition?

## 2.2 Europe's Dilemma: Running as a Team?

Now let's talk about Europe. The subtitle of this presentation asks: *"Will Europe run as a team as fast?"*

The short answer: **Europe is not currently running as a team.**

### 2.2.1 The Fragmentation Problem

- **Germany:** Betting big on hydrogen (€12.5 billion), but ArcelorMittal withdrew, citing "unfavorable framework conditions"
- **Sweden:** H2 Green Steel pushing ahead with \$2.50-3/kg hydrogen (competitive), but outside EU subsidy framework
- **Austria:** voestalpine on track with Linz project, leveraging 80% hydropower
- **France:** Cautious, waiting for clearer hydrogen economics
- **Italy:** Limited action, focusing on EAF expansion
- **Poland:** ArcelorMittal demands electricity price guarantees before moving
- **Czech Republic:** Trinecké železářny *postponed* projects for 2+ years despite government support

Each country pursuing slightly different strategies. Each with different energy costs, different political priorities, different industrial structures.

**This is not a coordinated team effort.**



### 2.2.2 What "Running as a Team" Would Actually Require

For Europe to truly compete with China's speed and scale, we would need:

#### 1. Unified Energy Policy

- Equalized industrial electricity prices across EU-27
- Coordinated hydrogen infrastructure (not 27 national plans)
- Pan-European renewable build-out at China-like speed

#### 2. Coordinated Investment

- €100+ billion Industrial Decarbonization Bank
- Clear, stable 10-15 year funding commitments
- No national vetoes on strategic projects

#### 3. Strong CBAM Implementation

- Extends to downstream products by 2027 (not 2030)
- Robust anti-circumvention enforcement
- Global coordination (UK, Switzerland, Turkey alignment)

#### 4. Demand Aggregation

- EU-wide green steel quotas for automotive
- Public procurement mandates
- Coordinated buyer coalitions

#### 5. Just Transition Funds

- Support for 100,000+ affected workers
- Regional economic development (Ruhr, Saar, Silesia)
- Retraining and mobility programs

**Current reality:** We have *some* of these elements, *partially* implemented, with *uncertain* commitment.

China, meanwhile, implements centralized policy across 1,015 Mt of production in *months*.

## 2.3 The Speed Question

Let me give you a concrete comparison:

### POLICY TO IMPLEMENTATION TIMELINE

#### China's Scrap-EAF Expansion:

- Policy announced: Oct 2024
- Implementation: Immediate
- Results: 214 → 300 Mt scrap mobilized in 18 months
- Projects approved: 7.1-7.2 Mt new EAF capacity in 6 months

#### Germany's H-DRI Projects:

- Policy announced: 2020-2021
- Subsidies allocated: 2022-2023
- Projects sanctioned: 2024-2025
- First production: 2027-2028 (target)
- Full implementation: 2030-2035

#### Time from policy to first production:

- China: **6-12 months**
- Germany: **7-10 years**

#### Why the difference?

1. China chose proven technology (EAF), Germany chose unproven (H-DRI at scale)
2. China has centralized decision-making, Europe has fragmented approvals
3. China prioritizes speed, Europe prioritizes perfection
4. China accepts "good enough" decarbonization (60-70%), Europe demands "near-perfect" (90%+)

*[Pause for emphasis]*

I'm not saying China's approach is better in all respects. But I *am* saying it's **faster**, and in a climate crisis, speed matters.

## 3 Today's Focus: The German-Speaking Test Case

### 3.1 Why Start with Germany and Austria? [3 minutes]

For today's presentation, we focus specifically on Germany and Austria—the German-speaking countries at the heart of European steel. Why?

1. **Germany is Europe's largest producer** (37.2 Mt, 30% of EU-27)
2. **Germany received 75% of EU steel decarbonization funds** (€7 billion+)
3. **Germany's hydrogen bet is the most aggressive** (€12.5 billion, 4 major projects)
4. **Austria offers a contrasting model** (smaller scale, hydropower advantage, single focused player)
5. **Together they represent the "premium European approach"** (\$650/tonne value-added vs \$270 global average)

If Germany and Austria succeed, they validate the European model. If they fail, the entire EU approach is questioned.

### 3.2 Germany: The €12.5 Billion Gamble

#### 3.2.1 The Four Pioneer Projects

Germany is betting its industrial future on four major hydrogen steel projects:

1. **ThyssenKrupp Steel - tkH2Steel®**
  - Concept: Replace 4 coal blast furnaces with H-DRI plants
  - Capacity: 2.5 Mt initially, scaling to 5 Mt by 2030
  - Impact: -3.5 Mt CO/year (20% of company emissions)
  - Innovation: First-time liquefaction of H-reduced iron
  - Challenge: H tender *paused* March 2024—prices €9.35/kg vs €4.50/kg target
  - Bridge: Natural gas DRI initially, transition to 100% H by 2045
  - Market: Pre-orders from VW, BMW, Mercedes (500,000 t first year)
2. **Salzgitter AG - SALCOS®**
  - Full name: Salzgitter Low CO Steelmaking
  - Target: 95% emissions reduction by 2033
  - Milestone: 100 MW electrolyzer completed early 2025 (9,000 t/year green H)

- Energy: Wind-powered, ensuring renewable credentials
- Strategy: Dual approach—on-site production + external procurement
- Status: Viewed as "decarbonization darling" by analysts

### 3. Stahl-Holding-Saar (SHS)

- H tender: March 2024 for up to 50,000 t/year renewable H
- Timeline: 2027-2029 commissioning
- Commitment: Maintained despite industry headwinds
- Regional importance: Critical for economically struggling Saarland

### 4. ArcelorMittal Germany - PROJECT WITHDRAWAL (June 2024)

- **THE WARNING SIGN:** Withdrew from all German subsidies
- Reason: "Unfavorable framework conditions"—not viable even with 50% subsidy
- Specific issues:
  - Hydrogen €9+/kg (more than double forecasts)
  - Electricity costs (€300M extra in 2024 alone)
  - Slow H economy development
  - Political/market uncertainty
- Impact: Forfeited all state support, resonated widely across sector
- Lesson: *"Even substantial public subsidies insufficient without competitive energy costs"*

#### 3.2.2 The ArcelorMittal Withdrawal: A Critical Moment

I want to pause on ArcelorMittal's June 2024 withdrawal because it represents a **pivotal moment** in the European steel decarbonization story.

Here's a company—the world's second-largest steelmaker—that:

- Had been *awarded* substantial German subsidies
- Had developed detailed engineering plans
- Had committed publicly to the transition
- **Walked away** because the economics didn't work

Thomas Bünger, CEO of ArcelorMittal Germany, stated clearly: Electricity at €50-55/MWh would be acceptable for EAF-based steelmaking. But German prices are €70-80/MWh with peaks above €100/MWh.

**The math is brutal:**

- Green steel production cost: €820-1,060/tonne
- Traditional steel with CBAM (€80/t CO): €550-690/tonne
- Gap: €270-370/tonne that must be covered by premiums or subsidies

ArcelorMittal's message: *We cannot bridge that gap even with your generous subsidies.*

### 3.3 Austria: The Alpine Advantage

Now let's contrast this with Austria—a smaller producer with structural advantages:

#### 3.3.1 voestalpine's Linz GreenTec Steel Project

- **Company:** voestalpine AG—Austria's steel champion, 48,000 employees globally
- **Site:** Linz—5.2 Mt/year capacity, Austria's largest industrial CO emitter (10 Mt/year)
- **Investment:** €1.5 billion (largest industrial project in Austrian history)
- **Technology:** Two electric arc furnaces + H-based DRI plant
- **Capacity:** 2.5 Mt/year green steel (nearly 50% of Austrian production)
- **Impact:** -5 Mt CO/year (30% of Austria's industrial emissions)
- **Energy:** 6 TWh/year additional green electricity (10% of Austria's current total)
- **Hydrogen:** 50,000 t/year green H by 2030, scaling to 100,000+ by 2035
- **Funding:** €750 million state support
- **Timeline:** Construction started 2024, first green steel 2027, full operation 2028-29
- **Status:** **ON TRACK**—regulatory approvals secured

#### 3.3.2 Austria's Structural Advantages

1. **Hydropower dominance:** 80% renewable electricity already (vs Germany 55%)
2. **Lower energy costs:** €40-60/MWh average (20-30% below Germany)
3. **Political consensus:** Cross-party support for industrial decarbonization
4. **Single champion:** voestalpine's dominance enables coordinated strategy
5. **Alpine hydrogen potential:** Large-scale hydropower electrolysis feasibility
6. **EU integration:** Strong connections to Italian, German, Czech markets

### 3.3.3 Germany vs Austria: Head-to-Head Comparison

Let me give you a direct comparison:

Factor	Germany	Austria
Production	37.2 Mt/year	7.2 Mt/year
Electricity cost	€50-80/MWh	€40-60/MWh ()
Renewable share	55%	80% ()
Complexity	4 major projects	1 player ()
Political stability	2025 elections risk	Stable ()
Market access	Domestic + export	Export-dependent ()
Investment risk	High (AM exit)	Medium-Low ()
Scale advantages	Large	Small ()

**Verdict:** Austria has *structural cost advantages* but Germany has *scale and market power*.

The interesting possibility: **Austria could emerge as the "Switzerland of Green Steel"** - small, premium, successful—while Germany struggles with the economics of large-scale transition.

## 3.4 The Cost Conundrum: Why Energy Prices Matter More Than Subsidies

Both Germany and Austria face the same fundamental challenge: **hydrogen and electricity costs**.

### 3.4.1 Current State (2024-2025)

- **Hydrogen market price:** €9-10/kg
- **Hydrogen viability threshold:** €4-4.50/kg
- **Gap:** 2-2.2x too expensive
- **German electricity:** €50-80/MWh (peaks >€100)
- **Austrian electricity:** €40-60/MWh
- **Competitive benchmark:** €30-40/MWh

**For context:**

- Sweden's H2 Green Steel: €2.50-3/kg hydrogen (hydropower-based)
- Middle East potential: €1.50-2/kg hydrogen (solar-based)
- Chinese electricity (industrial): €30-45/MWh

### 3.4.2 Why This Matters More Than Subsidies

ArcelorMittal's withdrawal teaches us: **You cannot subsidize your way out of a 2-3x cost disadvantage.**

Consider the math for a 2 Mt/year green steel plant:

**Annual hydrogen requirement:** ~80,000 tonnes

**At €9/kg:** €720 million/year

**At €4.50/kg:** €360 million/year

**At €3/kg (Sweden):** €240 million/year

**Cost difference Germany vs Sweden:** €480 million/year

**German subsidy:** Even at 50% CAPEX support (~€750M one-time), it doesn't cover *ongoing* OPEX disadvantage.

**Over 10 years:** Swedish plant saves €4.8 billion in hydrogen costs alone compared to German plant.

*This is why ArcelorMittal walked away.*

## 4 Three Scenarios for 2035: Where Are We Headed?

### 4.1 Scenario Methodology [2 minutes]

For the German-speaking bloc (and later, for other regions in MIFUS), I've developed three scenarios based on:

- Hydrogen cost trajectories
- Electricity price developments
- CBAM effectiveness
- Political stability and funding continuity
- Market demand for green steel
- Chinese competitive pressure

These aren't wild guesses—they're grounded in current project economics, announced policies, and historical industrial transitions.

### 4.2 Scenario A: "Green Steel Champions" (20-25% probability)

**What happens:**

- H costs fall to €3-3.50/kg by 2030 (aggressive electrolyzer cost reduction + cheap renewables)
- Electricity costs reduced 30-40% through policy intervention
- CBAM implemented effectively, protecting EU market
- Strong demand for green steel, sustained premiums
- All major projects proceed on schedule

**Outcomes in 2035:**

- **Production:** 30-35 Mt green steel (down from 44.6 Mt today, but profitable)
- **Employment:** 85,000 jobs (down 11% from 95,000)
- **Emissions:** 80% reduction achieved
- **Economics:** Profitable without ongoing subsidies
- **Global position:** Technology leaders, exporters of know-how



- **Value-added:** Maintain \$650/tonne premium

**Regional split:**

- Germany: 25-28 Mt, consolidated to 2-3 major hubs (Ruhr, Salzgitter)
- Austria: 5-7 Mt, Linz becomes European green steel showcase

**Key enablers:**

1. Political miracle: EU-wide energy price equalization
2. Technology breakthrough: Electrolyzer costs <€300/kW
3. Market miracle: Automotive/construction willing to pay 15-20% green premium
4. Policy success: CBAM actually works, no circumvention

**Probability assessment: 20-25%**

Why so low? Because it requires *everything* to go right simultaneously.

### 4.3 Scenario B: "Managed Contraction" (50-60% probability) - BASE CASE

**What happens:**

- H costs fall to €4.50-5/kg by 2032 (slower than hoped, but viable)
- Electricity costs improve modestly (10-15% reduction)
- CBAM partially effective (some circumvention, downstream gaps)
- Moderate demand for green steel, limited premiums
- Some projects delayed/scaled back, but core proceeds

**Outcomes in 2035:**

- **Production:** 20-25 Mt (down 45-55% from today)
- **Employment:** 65,000 jobs (down 32%)
- **Emissions:** 60% reduction (respectable but short of targets)
- **Economics:** Marginally profitable, subsidy-dependent for another decade
- **Global position:** Niche premium producer, not technology leader
- **Value-added:** Maintain \$500-550/tonne (premium compressed)

### **Regional split:**

- Germany: 15-19 Mt, 1-2 major exits (Bremen? Saar?), consolidation around survivors
- Austria: 5-6 Mt, Linz succeeds but limited growth

### **Characteristics:**

- Hybrid technology mix: Some H-DRI, significant natural gas bridge, expanded EAF
- Permanent subsidy dependency for green steel premium
- Continued imports (40-45% of EU consumption)
- Just-transition challenges: 30,000 job losses

### **Key assumptions:**

1. Political reality: Modest improvements but no transformation
2. Technology reality: Incremental progress, no breakthroughs
3. Market reality: Green steel niche, not mainstream
4. Policy reality: CBAM works somewhat, but not perfectly

### **Probability assessment: 50-60% - BASE CASE**

This is the most likely outcome because it reflects *realistic* progress without requiring miracles.

## **4.4 Scenario C: "Industrial Decline" (20-25% probability)**

### **What happens:**

- H costs remain  $\leq \text{€}7/\text{kg}$  through 2035 (slow infrastructure, expensive renewables)
- Electricity costs stay high or increase further
- CBAM fails (circumvention, WTO challenges, political backsliding)
- Weak demand for green steel, no sustained premiums
- Multiple major project cancellations after initial investments

### **Outcomes in 2035:**

- **Production:** 12-18 Mt (down 60-73% from today)

- **Employment:** 40,000 jobs (down 58%)
- **Emissions:** 40% reduction (from much lower base)
- **Economics:** Chronic losses, wave of bankruptcies/exits
- **Global position:** Lost competitiveness, import dependence
- **Value-added:** Falls to \$400-450/tonne (premium collapses)

**Regional split:**

- Germany: 10-15 Mt, Ruhr devastated, only 1-2 survivors (Salzgitter?), massive deindustrialization
- Austria: 2-3 Mt, even voestalpine scales back or mothballs Linz

**Characteristics:**

- Serial project failures (following ArcelorMittal's lead)
- Stranded assets: €10+ billion in abandoned investments
- Regional economic collapse (Ruhr, Saar become "rust belt")
- Political crisis: Industrial policy failure undermines climate credibility
- Import surge: 60-70% of EU steel from China, Turkey, India

**Trigger events:**

1. Energy crisis redux: Persistent high electricity/gas prices
2. Political instability: Funding commitments abandoned post-elections
3. Technology failure: H-DRI at scale proves unreliable
4. Market collapse: Chinese low-carbon steel floods Europe at \$400/tonne
5. CBAM collapse: WTO rules against EU, or major circumvention unchecked

**Probability assessment: 20-25%**

Not the base case, but *plausible* given current risks.

## 4.5 Scenario Implications: What They Tell Us

*[This is a key analytical moment—slow down, make eye contact]*

Notice something critical about these scenarios:

### THE ASYMMETRY OF OUTCOMES

**Success scenario (A):** Requires everything to go right

**Base scenario (B):** Accepts significant losses/contraction

**Failure scenario (C):** Requires only a few things to go wrong

This is an **asymmetric risk profile**. The *downside* is more likely than the *upside*.

Why? Because Germany and Austria are betting on:

- **Unproven technology** (H-DRI at commercial scale)
- **Uncompetitive costs** (2-3x disadvantage vs Sweden/Middle East)
- **Uncertain policy** (CBAM effectiveness, subsidy continuity)
- **Market novelty** (green steel premium unproven at scale)

Meanwhile, China is betting on:

- **Proven technology** (EAF-scrap, established for decades)
- **Competitive costs** (domestic scrap, cheap electricity)
- **Certain policy** (centralized decision-making, fast implementation)
- **Market dominance** (53% global production, price setter)

**Question for the course:** Is Europe's high-risk, high-reward strategy wise? Or should we have followed China's pragmatic path?

## 5 Interlude: The Language of Steel - A Unique Perspective

### 5.1 Why Analyze Steel Through Language? [3 minutes]

Before we continue with policy recommendations, I want to share something unusual—an analytical framework I developed specifically for MIFUS.

We often analyze steel by *country* (China, Germany, USA) or by *company* (Arcelor-Mittal, Baosteel, ThyssenKrupp). But what if we analyze it by **language**?

Why? Because language correlates with:

- **Industrial culture** (German *Gründlichkeit*, Japanese *Kaizen*, Chinese /speed)
- **Technology transfer** (engineering knowledge flows within language blocs)
- **Trade networks** (linguistic ties facilitate supply chains)
- **Policy coordination** (or lack thereof—EU’s multilingualism complicates vs China’s unified Mandarin)

This isn’t just academic curiosity—it reveals *structural advantages and disadvantages*.

### 5.2 Key Findings: Steel Production by Linguistic Bloc (2024)

Top 10 Language Blocs by Production:

Rank	Language	Mt/year	Global %	t/capita	\$/tonne
1	Mandarin Chinese	1,015	53.4%	0.91	220
2	English	185	9.7%	0.13	350
3	Japanese	87	4.6%	0.70	580
4	Hindi/Urdu	82	4.3%	0.12	170
5	Russian	76	4.0%	0.29	260
6	Korean	67	3.5%	0.82	520
7	<b>German</b>	<b>45</b>	<b>2.4%</b>	<b>0.34</b>	<b>650</b>
8	Turkish	41	2.2%	0.47	280
9	Spanish	37	1.9%	0.07	310
10	Italian	24	1.3%	0.28	480

### 5.3 The German-Speaking Paradox

Here’s what jumps out:

### GERMAN-SPEAKING BLOC PARADOX

**Production:** 2.4% of global volume (45 Mt)

**Value:** 5.7% of global value (\$29.3 billion)

**Multiplier:** 2.4x (produce 2.4%, capture 5.7%)

**Price premium:** \$650/tonne vs \$270 global average (2.4x)

**Key comparison:**

- German steel: \$650/t
- Chinese steel: \$220/t
- Hindi-bloc steel: \$170/t

**Premium:** 3x vs Chinese, 4x vs Hindi-bloc

**What this premium reflects:**

- Specialty steel (automotive, precision engineering)
- Advanced processing (tight tolerances, complex alloys)
- Brand value ("Made in Germany")
- Quality reputation (centuries of tradition)
- Service and reliability

**But also:**

- High labor costs
- Energy cost disadvantage
- Stringent environmental/safety standards
- Complex regulatory environment

## 5.4 Productivity: Value-Added per Worker

Even more revealing—productivity metrics:

Language	VA/Worker (\$k)	Workers/1000t	Automation
Japanese	459	1.26	Ultra-high
Italian	411	1.17	High
Korean	409	1.27	Ultra-high
German	308	2.11	Very high
English (avg)	270	1.30	High
Chinese	147	1.50	Mid
Hindi/Urdu	85	2.00	Low

**Surprising finding:** German steel employs *more* workers per tonne (2.11) than Japan (1.26) despite comparable wages.

**Why?**

1. Higher specialty steel share (labor-intensive)
2. Stronger unions maintaining employment
3. Legacy workforce from coal-based production
4. Integrated mills vs Japan's coastal mega-plants

**Implication for decarbonization:** Green steel projects (DRI-EAF) require 30-40% fewer workers than BF-BOF. Even in *success* scenario, 20,000-30,000 German-speaking jobs disappear.

## 5.5 The 2035 Linguistic Landscape

Based on our scenarios, here's how language blocs might look in 2035:

**Winners:**

- **Mandarin:** 55-60% global share (up from 53%), commodity + premium
- **Korean:** Maintain 3-4%, premium niche
- **Japanese:** Maintain 4-5%, ultra-premium niche
- **Vietnamese:** 2-3% (up from 1.2%), fast-growing commodity

**Stable:**

- **English:** 9-10%, bifurcated (US premium, India commodity)
- **Turkish:** 2-2.5%, regional power

**At Risk:**

- **German:** 1.5-3% (down from 2.4%), depends on scenario

- **Russian:** 2-3% (down from 4%), sanctions/stagnation
- **Ukrainian:** -0.5% (war devastation)

**The German Question:** Can a language bloc representing 1.7% of global population sustain 2-3% of global steel production at 2-3x cost premium?

*That's what the next decade will answer.*



## 6 What Should Be Done? Policy Recommendations

### 6.1 For European Governments [4 minutes]

Based on our analysis, here are the critical policy interventions needed:

#### 6.1.1 1. Energy Cost Action (IMMEDIATE PRIORITY)

**The Problem:**

- German industrial electricity: €50-80/MWh
- Competitive benchmark: €30-40/MWh
- Swedish advantage: €25-35/MWh
- This 50-100% disadvantage cannot be subsidized away

**Solutions:**

- **Reduce network charges 30-40%** for industrial users
- **Facilitate long-term PPAs** (Power Purchase Agreements) directly with renewables
- **EU-wide industrial electricity price equalization mechanism**
- **Target: €30-40/MWh for industrial consumers by 2027**

**Cost:** €2-3 billion/year across EU (compare: €10+ billion at stake in steel subsidies)

**Rationale:** If we don't fix energy costs, *all other investments are wasted.*

#### 6.1.2 2. Hydrogen Price Support (STRUCTURED INTERVENTION)

**The Problem:**

- Current H price: €9-10/kg
- Viability threshold: €4-4.50/kg
- Market won't deliver this price before 2030-2035 without intervention

**Solution: Carbon Contracts for Difference (CCfD)**

- **Strike price:** €4-4.50/kg
- **Duration:** 10-15 years
- **Mechanism:** Government pays difference between market price and strike price

- **Volume:** Guaranteed offtake for 200,000-300,000 t/year H (German-Austrian needs)
- **Cost:** €2-3 billion/year initially, declining as market prices fall

**Precedent:** UK's CCfD for offshore wind (highly successful)

**Critical:** This creates *investment certainty* for both H producers and steel consumers.

### 6.1.3 3. Infrastructure Priority (BOTTLENECK REMOVAL)

#### The Problem:

- Hydrogen core network delayed 2-3 years
- Grid capacity insufficient for increased EAF loads
- Renewable build-out too slow (need +115 TWh/year for German-Austrian steel alone)

#### Solutions:

- **Accelerate hydrogen core network** - connect Duisburg/Salzgitter/Saar/Linz by 2027 (not 2030)
- **Fast-track grid reinforcement** for steel sites (bypass normal approval processes)
- **Co-locate renewable generation** with steel production where possible
- **Priority permitting** for steel-critical energy infrastructure

**Model:** Germany's LNG terminal build-out (2022-2024)—proved fast infrastructure development possible when political will exists.

### 6.1.4 4. CBAM Strengthening (TRADE PROTECTION)

#### The Problem:

- Current CBAM covers direct steel products only
- Downstream products excluded until 2030 (screws, bolts, simple assemblies)
- This creates massive circumvention loophole
- Third-country transshipment risk (Turkey, UK, Ukraine used as intermediaries)

#### Solutions:

- **Extend to downstream products by 2027** (not 2030)—accelerate 3 years
- **Robust anti-circumvention measures:** Origin verification, production tracking

- **Third-country alignment:** UK, Switzerland, Norway, Turkey must implement equivalent measures
- **Strict enforcement:** Customs audits, penalties for false declarations
- **Scope expansion:** Include embodied emissions in complex products (automotive, machinery)

**Alternative:** If CBAM cannot be strengthened, the entire green steel strategy collapses.

### 6.1.5 5. Policy Continuity (POLITICAL COMMITMENT)

#### The Problem:

- Germany faces 2025 federal elections
- Austria's coalition fragile
- 10-15 year project timelines vs 4-5 year political cycles
- Investment decisions require certainty

#### Solutions:

- **Cross-party agreements** on steel decarbonization funding (beyond election cycles)
- **Legal guarantees** for approved subsidies (cannot be revoked by future governments)
- **Independent oversight body** monitoring implementation
- **EU-level coordination** reducing dependence on national politics

**Model:** Germany's *Energiewende* broad political consensus (maintained across multiple governments)

## 6.2 For Steel Companies [3 minutes]

Companies cannot just wait for perfect policy—they must act strategically:

### 6.2.1 1. Embrace Bridge Strategies

**Don't wait for 100% green hydrogen:**

- Use **natural gas DRI transitionally** (60-70% emissions reduction immediately)
- Install **H-ready equipment** (can increase H blend over time)
- Start with **20-40% H blends**, increase as availability improves
- **Don't let perfect be enemy of good**

**Rationale:** Waiting for 100% H at competitive prices might mean waiting until 2035-2040—too late.

### 6.2.2 2. Secure Offtake Agreements

**Before Final Investment Decision:**

- **Binding contracts for 70%+ of planned green steel production**
- **Minimum 5-10 year terms**
- **Price formulas linked to H/electricity costs** (pass-through mechanisms)
- **Take-or-pay commitments** from automotive/construction customers

**Example:** ThyssenKrupp's pre-orders from VW/BMW/Mercedes for 500,000 t—this is right approach.

**Lesson from ArcelorMittal withdrawal:** Without guaranteed demand at viable prices, projects don't proceed.

### 6.2.3 3. Diversify Hydrogen Sources

**Don't depend on single H supplier:**

- **On-site electrolysis** where electricity is cheap (20-30% of needs)
- **Pipeline contracts** with multiple suppliers (40-50%)
- **Imported derivatives** (ammonia, methanol) as backup (10-20%)
- **Storage capacity** for price arbitrage and supply security

**Rationale:** H market will be volatile for next decade—resilience requires diversity.

#### 6.2.4 4. Right-Size Capacity

Be realistic about demand:

- ThyssenKrupp's reduction 11.5 Mt → 9 Mt was **wise**, not failure
- Better to be profitable at 70% of current capacity than unprofitable at 100%
- Focus on **high-value products** where green premium can be sustained
- **Exit commodity segments** where cost competition is brutal

**Painful truth:** German-speaking bloc likely shrinks 30-50% even in success scenario.

### 6.3 For the European Union [2 minutes]

EU-level actions that member states cannot do alone:

#### 6.3.1 1. Industrial Decarbonisation Bank

Proposal:

- **€100 billion dedicated facility** for heavy industry decarbonization
- **Long-term loans** (15-20 years) at favorable rates (2-3%)
- **First-mover priority** (reward early movers, don't wait for laggards)
- **Cross-border projects prioritized** (e.g., German-Austrian H corridor)

**Current state:** EU Innovation Fund has €40 billion—insufficient and slow-disbursing.

#### 6.3.2 2. Demand Aggregation

Create EU-wide green steel market:

- **Public procurement mandates:** 30% green steel for infrastructure by 2028
- **Automotive quotas:** Graduated requirements for green steel content
- **Buyer coalitions:** Facilitate long-term contracts between producers/consumers
- **Certification standards:** EU-wide green steel definition and labeling

**Rationale:** Fragmented national demand insufficient—need European scale.

### 6.3.3 3. Just Transition Fund (Steel-Specific)

**Reality:** 50,000-100,000 EU steel jobs at risk

**Needed:**

- **€5-10 billion dedicated fund** for steel regions
- **Retraining programs** for H/renewable energy sectors
- **Regional economic development** (Ruhr, Saar, Silesia, etc.)
- **Early retirement packages** for workers 55+
- **Mobility support** for younger workers

**Political necessity:** Without credible just transition, political support collapses.

## 7 The MIFUS Course: What We'll Explore Together

### 7.1 Course Philosophy [2 minutes]

Now that you've seen the complexity of just *one* region (German-speaking countries), imagine multiplying this across:

- 20+ steel-producing countries
- 6-8 distinct technology pathways
- Multiple policy frameworks
- Divergent economic models
- Competing geopolitical interests

**This is why MIFUS is structured as a journey.**

We cannot understand steel decarbonization by studying technologies in isolation. We must understand:

- **Context:** Why does Sweden succeed where Germany struggles?
- **Trade-offs:** Why did China choose EAF over H-DRI?
- **Path dependency:** Why is India locked into coal-based production for another decade?
- **Political economy:** Why do subsidies work in some countries but not others?

### 7.2 Course Structure: The Itinerary

#### Part 1: European Frontiers (Weeks 1-4)

1. **Germany & Austria** (Today's focus) - The H bet
2. **Sweden & Finland** - Nordic advantage, competitive H
3. **France & Belgium** - Nuclear power, cautious approach
4. **Italy & Spain** - EAF dominance, scrap strategy
5. **Poland & Czech Republic** - Coal transition, political challenges

#### Part 2: Asian Giants (Weeks 5-8)

6. **China** (Deep dive) - The pragmatic revolution, EAF+scrap, policy speed
7. **Japan** - Ultra-premium, H-DRI pilots, CCUS exploration

8. **South Korea** - Green New Deal, POSCO's strategy
9. **India** - Coal dependency, slow transition, future potential

### **Part 3: Americas & Emerging (Weeks 9-11)**

10. **United States** - EAF dominance (70%), IRA impacts, tariff protection
11. **Brazil** - Charcoal route, Amazon concerns, competitive advantage
12. **Turkey, Middle East, Africa** - Regional powers, diverse strategies

### **Part 4: Synthesis & Future (Weeks 12-14)**

13. **Technology Comparison** - Which pathways win? Cost curves, TRL assessment
14. **Global Trade Flows** - CBAM, tariffs, green steel markets
15. **2050 Scenarios** - Who survives? Who thrives? Final projections

## **7.3 Pedagogical Approach**

**Each country/region module includes:**

1. **Technical deep-dive (30%)**
  - Production processes, technology choices, efficiency metrics
  - Material flows, energy inputs, emissions profiles
2. **Economic analysis (30%)**
  - Cost structures, price competitiveness, subsidy dependence
  - Investment requirements, payback periods, risk assessment
3. **Policy & politics (20%)**
  - Government strategies, regulatory frameworks, political economy
  - Trade policy, carbon pricing, industrial policy
4. **Comparative perspective (20%)**
  - How does this country compare to others?
  - What can we learn? What should be avoided?

**Assessment:**

- **Weekly case studies:** Analyze specific projects (ThyssenKrupp, Baosteel, etc.)



- **Mid-term project:** Deep-dive report on one country of your choice
- **Final project:** Scenario analysis for 2035—your own projections with justification
- **Class debates:** "Should Europe have chosen China's EAF strategy?" etc.

## 7.4 Learning Outcomes

By the end of MIFUS, you will be able to:

### 1. Technical mastery:

- Explain all major steelmaking routes (BF-BOF, DRI-EAF, scrap-EAF)
- Calculate emissions profiles and decarbonization potentials
- Assess technology readiness levels and commercialization risks

### 2. Economic literacy:

- Perform cost-benefit analysis of decarbonization investments
- Understand energy economics (why electricity/H prices matter more than subsidies)
- Evaluate business cases for green steel projects

### 3. Strategic thinking:

- Identify which countries/companies will succeed or fail
- Explain why similar policies produce different outcomes in different contexts
- Develop evidence-based scenarios for industry evolution

### 4. Critical perspective:

- Question official narratives and company claims
- Recognize when political rhetoric diverges from technical/economic reality
- Understand trade-offs between speed, cost, and perfection

## 7.5 Why This Matters for Your Future

*[Personal connection—important for student engagement]*

Some of you will work in:

- **Steel companies** making these transition decisions
- **Automotive/construction** companies sourcing green steel

- **Engineering firms** designing DRI plants or electrolyzers
- **Consulting firms** advising on industrial decarbonization
- **Government agencies** crafting climate policy
- **Financial institutions** evaluating project investments
- **International organizations** (EU Commission, OECD, etc.)

Understanding steel decarbonization is understanding how *industrial transformation actually happens*—or fails to happen.

The lessons from steel apply to:

- Cement (2nd largest industrial emitter)
- Chemicals (3rd largest)
- Aluminum, glass, paper...

MIFUS prepares you for the industrial transformations of the next 20-30 years.

## 8 Closing: The Questions That Will Define the Next Decade

### 8.1 Returning to Our Central Question [3 minutes]

*[Bring it full circle—reference the opening]*

We began with the question: **”China is running fast, will Europe run as a team as fast?”**

After examining Germany and Austria in detail, what’s the answer?

#### 8.1.1 China IS Running Fast

The evidence is clear:

- **October 2024 policy revolution** - Zero new BF-BOF approvals
- **EAF share 10% → 15% in 18 months** - Fastest deployment globally
- **Scrap mobilization 214 → 300 Mt/year** - Infrastructure at scale
- **-53 Mt CO in 2024-2025** - Larger than Germany’s entire steel emissions
- **Policy to implementation: 6-12 months** - Unprecedented speed

China chose:

- **Pragmatic technology** (EAF+scrap, proven)
- **Affordable costs** (\$300-400/t achievable)
- **Fast deployment** (immediate action)
- **Scale advantage** (53% global production)

#### 8.1.2 Europe Is NOT Running as a Team

The evidence is equally clear:

- **27 different national strategies** - No coordination
- **Energy price disparities 50-100%** - No level playing field
- **Subsidy fragmentation** - Each country negotiates separately
- **CBAM loopholes** - Downstream products unprotected until 2030
- **Major project withdrawals** - ArcelorMittal Germany, others paused

- **Timeline slippage** - 7-10 years policy to production

Germany/Austria chose:

- **Risky technology** (H-DRI at commercial scale unproven)
- **Expensive costs** (\$800-1,000/t, subsidy-dependent)
- **Slow deployment** (2027-2030 targets, uncertain)
- **Scale disadvantage** (2.4% global production)

## 8.2 The Uncomfortable Truths

*[This is where academic honesty matters—don't sugarcoat]*

### Truth #1: Europe's hydrogen bet might be too expensive

Even with massive subsidies, German green steel at €800-1,000/tonne cannot compete with Chinese low-carbon steel at €400-500/tonne unless:

- CBAM works perfectly (uncertain)
- Customers pay 50-100% premium for "Made in Germany" green credentials (unproven at scale)
- Hydrogen costs fall 60% in 5 years (optimistic)

### Truth #2: Speed matters more than perfection

China's 60-70% decarbonization via EAF achieved in 2025-2028 delivers more climate benefit than Europe's 90% via H-DRI achieved in 2030-2035 (if achieved at all).

The atmosphere doesn't care about technology elegance—it cares about *actual emissions reduced*.

### Truth #3: Industrial policy requires industrial-scale commitment

Germany's €12.5 billion sounds impressive until you realize:

- China invests estimated €50+ billion in steel transformation
- USA's IRA allocates €12 billion for steel alone
- This is spread across 37.2 Mt vs China's 1,015 Mt
- Per-tonne support: Germany €335/t, China €49/t—but China's base costs are lower

### Truth #4: Europe is not running as a team

Until we have:

- Unified energy pricing

- Coordinated hydrogen infrastructure
- Strong CBAM with no loopholes
- Pooled investment funds
- Aligned political commitment

...we're 27 individual runners, not a relay team.

### 8.3 But There IS Hope

*[Important—don't end on despair, but don't be naively optimistic either]*

The situation is challenging, but not hopeless. Here's why:

#### **Reason #1: European engineering excellence is real**

German and Austrian companies are developing technology that, if successful, will be the *best* in the world. Japan, Korea, and other premium producers are following European leads, not Chinese.

If H-DRI works at scale, Europe becomes the technology exporter for the next 30 years.

#### **Reason #2: Green premium might materialize**

Early evidence suggests customers *will* pay for verified green steel:

- VW, BMW, Mercedes pre-orders at premium prices
- Apple, Google demanding low-carbon materials
- Construction sector moving toward embodied carbon limits

The \$650/tonne German premium has existed for decades—it might persist in low-carbon era.

#### **Reason #3: CBAM can still work**

If the EU:

- Extends to downstream products by 2027
- Enforces rigorously
- Coordinates with UK, Switzerland, Norway, Turkey

...then Europe creates a *protected market* of 500+ million people where green steel competes fairly.

#### **Reason #4: Austria shows it's possible**

voestalpine's Linz project is *on track*:

- Leveraging 80% hydropower base

- 20-30% cheaper electricity than Germany
- Political consensus holding
- Construction started, 2027 first production

If Austria succeeds, it proves the model can work—*with the right structural conditions*.

#### **Reason #5: Failure would be catastrophic, so political will might emerge**

The stakes are so high—100,000 jobs, €100+ billion invested, industrial sovereignty, climate credibility—that European leaders might finally coordinate.

The ArcelorMittal withdrawal was a *wake-up call*. Will Europe respond?

## 8.4 The Five Critical Questions for 2025-2030

As we embark on MIFUS, these are the questions that will shape outcomes:

### THE FIVE QUESTIONS

- 1. Energy Economics:** Will hydrogen costs fall to €4-4.50/kg by 2030? Will electricity reach €30-40/MWh?
- 2. Technology Viability:** Does H-DRI work reliably at commercial scale? Or will Europe pivot to China's EAF strategy?
- 3. Policy Effectiveness:** Does CBAM actually protect European producers? Or do circumvention and WTO challenges undermine it?
- 4. Market Reality:** Will customers pay 20-30% premiums for green steel? For how long? At what volumes?
- 5. Political Will:** Does Europe find the coordination and commitment to match China's centralized speed?

**By 2030, we'll have answers to all five.**

And those answers will determine which scenario—Green Steel Champion, Managed Contraction, or Industrial Decline—becomes reality.

## 8.5 What MIFUS Will Teach You

Through our journey across steel-producing nations, you'll learn to:

### 1. Analyze industrial transitions systematically

- Separate rhetoric from reality
- Identify critical success factors
- Recognize when projects will fail before they do

## 2. Understand technology-economics-policy interactions

- Why great technology fails with bad economics
- Why subsidies can't overcome structural disadvantages
- Why policy uncertainty kills investment

## 3. Think comparatively across different contexts

- Why Sweden succeeds where Germany struggles (hydropower advantage)
- Why China's pragmatism beats Europe's perfectionism (at least on speed)
- Why small countries (Austria) might outperform large ones (Germany)

## 4. Develop evidence-based scenarios

- Not wishful thinking ("everything works out")
- Not cynicism ("everything fails")
- But realistic assessment of probabilities and dependencies

## 8.6 The Journey Begins

*[Final inspirational close]*

We stand at a pivotal moment in industrial history. The decisions made in 2024-2030 will shape:

- The geography of 21st century steel production
- The competitiveness of European manufacturing
- The employment of millions of workers
- The emissions trajectory toward 2050
- The credibility of European climate leadership

**Germany and Austria are the test case.** If they succeed with their €14 billion hydrogen bet, they validate the European model and create a blueprint others will follow.

If they fail—if ArcelorMittal's withdrawal becomes a trend rather than an exception—Europe will be forced to reconsider its entire strategy.

**China has shown that fast, pragmatic decarbonization is possible** at 53% of global production. The question is whether Europe's pursuit of perfection will deliver superior outcomes, or whether it will simply deliver them too late and too expensively.

Over the coming weeks in MIFUS, we will:

- Visit steel mills from Duisburg to Shanghai
- Analyze projects from H2 Green Steel to Baosteel
- Debate strategies from carbon capture to electrification
- Project scenarios from 2030 to 2050

By the end, you will understand not just *how steel is made*, but *how industrial futures are won and lost*.

*Welcome to MIFUS: A Global Journey Through Steel Decarbonization.*



## A Appendix A: Key Statistics Summary

### A.1 German-Speaking Bloc (Germany + Austria + 70% Switzerland)

Metric	Germany	Austria	Combined
Production (Mt/year)	37.2	7.2	44.6
Global share	2.0%	0.4%	2.4%
EU-27 share	30%	6%	36%
CO emissions (Mt/year)	40-43	11-12	52
Direct employment	80,000	13,000	93,000
Total investment	€12.5 bn	€1.5 bn	€14 bn
Public funding	€6.9 bn	€0.75 bn	€7.65 bn
H target 2030 (t/year)	320,000	50,000	370,000
Renewable electricity need	105 TWh	10 TWh	115 TWh
Value-added (\$/tonne)	650	650	650

### A.2 Global Context - Top 10 Producers (2024)

Rank	Country	Mt/year	Global %
1	China	1,015	53.4%
2	India	140	7.4%
3	Japan	87	4.6%
4	USA	81	4.3%
5	Russia	76	4.0%
6	South Korea	67	3.5%
7	Germany	37.2	2.0%
8	Turkey	41	2.2%
9	Brazil	31	1.6%
10	Iran	30	1.6%
World Total		1,900	100%

## B Appendix B: Technology Comparison Matrix

Technology	TRL	Cost	CO	Speed	Risk	Leader
BF-BOF (coal)	9	Low	High	Fast	Low	China
BF-BOF + CCUS	6-7	High	Med	Slow	High	Japan
Natural gas DRI	8-9	Med	Med	Fast	Low	MENA
H-DRI (blend)	7-8	High	Low	Med	Med	EU/JP
H-DRI (100%)	6-7	V.High	V.Low	Slow	High	Sweden
EAF (scrap)	9	Low	Low	Fast	Low	USA/CN
Electrolysis	4-5	V.High	Zero	V.Slow	V.High	R&D

**Key:**

- TRL = Technology Readiness Level (1-9, higher = more mature)
- Cost = Relative production cost (Low = €500/t, High = €800/t)
- CO = Emissions intensity (High = 1.8t CO/t steel, Low = 0.5t)
- Speed = Deployment timeline (Fast = 3 years, Slow = 5 years)
- Risk = Technical/commercial risk (Low = proven, High = uncertain)

## C Appendix C: Cost Breakdown - Green vs Traditional Steel

### C.1 Traditional BF-BOF Steel (Germany, 2024)

Component	€/tonne
Iron ore	80-100
Coking coal	120-150
Energy	40-60
Labor	50-80
Capital (depreciation)	60-80
Other (maintenance, etc.)	50-70
<b>Subtotal</b>	<b>400-540</b>
CO cost (€80/t × 1.9t CO)	+150
<b>Total with CBAM</b>	<b>550-690</b>

### C.2 Green H-DRI-EAF Steel (Germany, 2024 costs)

Component	€/tonne
DRI-grade ore	100-120
Green H (@€9/kg × 50kg)	450-550
Green electricity	80-120
Labor	40-60
Capital (depreciation)	100-140
Other	50-70
<b>Subtotal</b>	<b>820-1,060</b>
CO cost	0
<b>Total</b>	<b>820-1,060</b>

**Cost gap:** €270-370/tonne that must be covered by:

- Green premium (customer willingness to pay)
- Subsidies (government support)
- Future H cost reductions (to €4-4.50/kg)

### C.3 Target Green Steel (2030, optimistic scenario)

Component	€/tonne
DRI-grade ore	100-120
Green H (@€4.50/kg × 50kg)	225-275
Green electricity	50-80
Labor	35-50
Capital	80-100
Other	40-60
<b>Total</b>	<b>530-685</b>

**At this cost:** Competitive with traditional steel + CBAM (~€550-690)

## D Appendix D: MIFUS Course Schedule

### D.1 Detailed Week-by-Week Plan

#### Week 1: Introduction & Germany

- Global steel overview, emissions challenge
- Germany's €12.5 billion hydrogen bet
- ThyssenKrupp, Salzgitter, SHS projects
- ArcelorMittal withdrawal analysis

#### Week 2: Austria & Alpine Advantage

- voestalpine Linz GreenTec Steel
- Hydropower advantage, cost competitiveness
- Small-country strategies
- Germany-Austria comparison

#### Week 3: Nordic Excellence - Sweden & Finland

- H2 Green Steel (Boden) - €4 billion megaproject

- Competitive hydrogen (€2.50-3/kg) from hydropower
- SSAB's HYBRIT program
- Why Sweden succeeds where Germany struggles

#### **Week 4: France, Belgium, Netherlands**

- Nuclear power advantage for electrification
- ArcelorMittal's European strategy (post-Germany exit)
- Port-based hydrogen import strategies
- EU policy coordination challenges

#### **Week 5: Italy & Spain - EAF Champions**

- 70%+ EAF share, scrap-based production
- Mediterranean advantages (solar, port access)
- Different decarbonization pathway from Germany
- Lessons for others

#### **Week 6: Eastern Europe - Poland, Czech, Slovakia**

- Coal dependency, difficult transitions
- Political challenges, cost pressures
- ArcelorMittal Poland demands electricity guarantees
- Just transition imperatives

#### **Week 7: China Part I - The October 2024 Revolution**

- Policy announcements, implementation speed
- EAF expansion 10% → 15% in 18 months
- Scrap mobilization 214 → 300 Mt/year
- Why China chose pragmatic over perfect

#### **Week 8: China Part II - Scale, Technology, Future**

- Baosteel, Ansteel, Shougang case studies
- National ETS integration, carbon markets

- Green steel exports, global competition
- 2030-2050 trajectory

### **Week 9: Japan - Ultra-Premium Strategy**

- Nippon Steel, JFE, Kobe Steel approaches
- H-DRI pilots, CCUS exploration
- \$580/tonne value-added, how sustained?
- Technology licensing, export strategy

### **Week 10: South Korea India**

- POSCO's Green New Deal strategy
- Korean shipbuilding steel demands
- India's coal lock-in, 140 Mt expansion
- Future potential vs current constraints

### **Week 11: USA, Brazil, Turkey, Middle East**

- USA: 70% EAF dominance, IRA impacts
- Brazil: Charcoal route, Amazon concerns
- Turkey: Regional EAF power
- Middle East: Green hydrogen potential

### **Week 12: Technology Deep-Dive**

- All pathways compared technically
- Cost curves, learning rates, scale effects
- TRL assessment, commercialization timelines
- Which technologies win?

### **Week 13: Global Trade & Policy**

- CBAM mechanics, effectiveness, circumvention
- US tariffs, Chinese export controls
- Green steel certification, standards

- Future trade architecture

## **Week 14: Synthesis & 2050 Scenarios**

- Who survives? Who thrives?
- Regional winners and losers
- Technology pathway dominance
- Your final scenario presentations

# **E Appendix E: Recommended Resources**

## **E.1 Essential Reading**

### **Technical:**

- World Steel Association: *Steel Statistical Yearbook 2024*
- IEA: *Iron and Steel Technology Roadmap*
- Mission Possible Partnership: *Making Net-Zero Steel Possible*

### **Policy:**

- European Commission: *IPCEI Hydrogen* documentation
- German BMWi: *Climate-Neutral Industry Program*
- Chinese NDRC: *Steel Industry Capacity Replacement Policy* (October 2024)

### **Industry Analysis:**

- McKinsey: *Decarbonization Challenge for Steel*
- BCG: *Green Steel Competitiveness Study*
- Wood Mackenzie: *Global Steel Decarbonization Outlook*

### **Company Reports:**

- ThyssenKrupp: *tkH2Steel® Technical Documentation*
- voestalpine: *greentec steel program updates*
- H2 Green Steel: *Investment prospectus*
- Baosteel: *Low-Carbon Development White Paper*

## E.2 MIFUS Online Resources

All course materials available at:

<https://www.gotrawama.eu/estep25udine/pdf/>

Including:

- Country-specific executive summaries (like today's Germany-Austria document)
- Technical datasheets on all major technologies
- Economic models and cost calculators
- Policy document archives
- Weekly case study assignments
- Scenario modeling tools

## F Appendix F: Questions for Reflection

*[These are questions to pose to students, either now or for next session]*

### F.1 Technical Questions

1. Why does H-DRI require "DRI-grade" ore? What happens if you use lower-grade ore?
2. Calculate: How much green electricity does Germany need to produce 320,000 t/year H via electrolysis?
3. Why can EAF use scrap but BF-BOF cannot? What are the metallurgical constraints?

### F.2 Economic Questions

1. If German H costs €9/kg and Swedish H costs €3/kg, should Germany import Swedish H or produce domestically?
2. Calculate the break-even green premium: At what \$/tonne price differential does green steel become competitive?
3. Why did ArcelorMittal withdraw even with 50% CAPEX subsidy? Work through the economics.

### **F.3 Strategic Questions**

1. Was China's choice of EAF+scrap over H-DRI strategic wisdom or climate compromise?
2. If you were CEO of ThyssenKrupp, would you proceed with the current project? Why or why not?
3. How should Austria leverage its hydropower advantage? Should it become a hydrogen exporter?

### **F.4 Policy Questions**

1. Design an optimal CBAM: What products, what carbon price, what enforcement mechanisms?
2. Should EU subsidies go to first-movers (Germany) or wait for lower costs (later movers)?
3. How do you balance climate ambition with industrial competitiveness?

### **F.5 Ethical Questions**

1. Is it acceptable for Europe to pursue 90% decarbonization slowly while China achieves 60% quickly?
2. What responsibility do we have to steel workers who lose jobs in the transition?
3. Should taxpayers subsidize private companies' decarbonization investments?



# Thank You

## MIFUS: A Global Journey Through Steel Decarbonization

*Steel Decarbonisation Policies:*

*China is Running Fast, Will Europe Run as a Team as Fast?*

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University of Udine, Italy

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🌐 <https://www.gotrawama.eu/estep25udine/pdf/>

*"From the Ruhr to Shanghai:*

*Understanding How Industrial Futures Are Won and Lost"*

Academic Year 2024-2025