Appendix A: Narrative scenarios for the European Union

Scenarios for the global steel transition

s-curve economics

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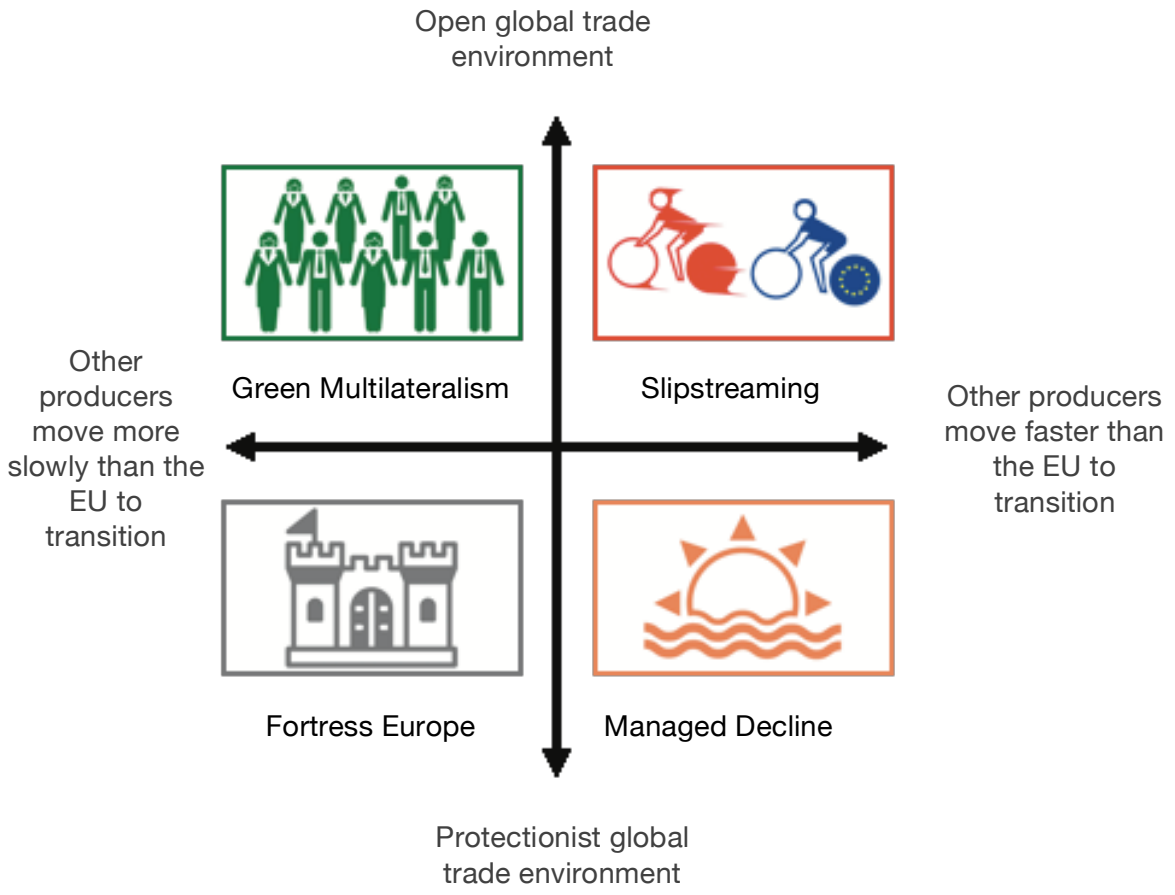

Green Multilateralism

Green Multilateralism describes a future where the global trade environment is open and where other producers move more slowly than the EU to transition to low carbon steel production.

Europe's steel industry has emerged as a market leader in low-carbon production. The EU has reached agreements with other major countries to ensure a level playing field for clean steel in international trade and its steel producers have become premium suppliers in a global market that increasingly values carbon credentials, traceability and regulatory certainty.

A convergence of interests

In the mid 2020s, the EU pushed ahead with steel decarbonisation in a bid to meet its climate targets and show the rest of the world what was possible. With the US dropping out of the clean energy technology race, the EU doubled down on its ambition to meet its climate goals and

improve its industrial competitiveness, with the aim that it could compete with China in future.

Europe's leadership initially created risks to the competitiveness of its own industry. As free allowances were wound down within the EU Emissions Trading System, the industry shouldered an increasing cost from carbon prices. The Carbon Border Adjustment Mechanism proved to be a weak defence: some overseas producers circumvented it by 'resource shuffling' (selling recycled steel to Europe and high-emission steel elsewhere); others by moving up the value chain and selling products made from steel that were not caught by the mechanism. Meanwhile, without any rebate of carbon pricing for exports, European steel was uncompetitive in overseas markets.

Faced with this risk, the EU shifted the focus of its domestic policies from carbon pricing to clean steel subsidies and demand creation. Existing clean steel plants had already received large amounts of public investment and the EU did not want to see these become 'green stranded assets'. It also radically revised its international approach: instead of leading by example and hoping others would follow, it began engaging in active diplomacy with the aim of establishing a level playing field for clean steel in international trade and creating new green iron supply chains to improve the EU's competitiveness.

Negotiations were tough, but gradually a convergence of interests emerged. China believed it could eventually surpass the EU in clean steel technology, given the huge resources of its steel industry. So did Brazil, due to its abundant iron ore and low-cost renewable energy. India, Japan, and South Korea had interests in energy security that aligned with the transition and wanted to retain access to the European market. The USA, fearful of being left out, joined the negotiations in 2028.

Floods, heat waves, droughts and fires continued with unprecedented ferocity during the late 2020s. The Intergovernmental Panel on Climate Change's sixth assessment report issued a stark warning that the window of opportunity to secure a liveable and sustainable future for all was closing rapidly. Its seventh assessment report, published in 2029, presented evidence that the jump in global temperatures in the mid 2020s was not an anomaly and that permafrost thaw, sea-ice melt, and other feedbacks were now driving a faster rate of warming.

As most countries had either failed to align their Nationally Determined Contributions (NDCs) with the Paris agreement goals or failed to align their policies with their emissions targets, support grew for focusing climate change diplomacy on practical cooperation.

The key measure of success

In 2030, the EU, China, India, Brazil, Japan, Korea and the USA – seven jurisdictions accounting for 80% of global steel production – signed the Comprehensive Agreement on Steel Trade and the Transition. This set out common guidelines on clean steel subsidies, reciprocal tariff reductions for near-zero emission primary steel, common definitions and standards, and a system to ensure transparency in production processes and traceability of steel products.

The Agreement finally aligned the forces of competition and trade with the transition to clean steel. Investment in hydrogen DRI steel plants surged globally.

Staying ahead

The EU's massive investment in clean power generation and distribution in the late 20s and early 30s, enabled by strong and consistent political support and funded by public-private partnership, has tripled Europe's renewable power capacity, modernised its electricity grids and storage

infrastructure. The EU super-grid ensures all member states have access to clean, low carbon energy.

The hydrogen backbone which now links low-cost iron production in Spain, Portugal, the North Sea, and Eastern Europe to demand centres in Germany, Benelux, Poland and elsewhere has dropped the cost of hydrogen and green DRI production, increased its availability and led to a restructured but more efficient and competitive steel value chain in Europe.

A global leader

Even despite restructuring, Europe's steel industry still requires more low-cost, green iron than it can produce domestically. EU Member States and Europe's steel producers have therefore built strong and trusted partnerships with countries that produce and export green iron cheaply - such as South Africa, Brazil and Australia - supporting these bilateral offtake agreements initially with government subsidies. They have increased the use of scrap steel in production, aided by strong policy measures that require product design to facilitate recycling and reuse of materials. Europe has also been able to remain open in its trade relationships due to its improved competitiveness globally and has avoided policies such as scrap export bans that would hinder the transition in other countries. As a result, interests in the transition have spread globally.

Blast furnaces have been gradually phased out without need for any strong regulation. Today, nearly 75% of EU crude steel is produced using hydrogen-based direct reduced iron and electric arc furnaces powered by renewable electricity.

The European industry is in a strong place. It has adapted to changing circumstances quickly and, by doing so, has moved ahead of the competition. It has invested in the technology required to make the transition and in the skills, processes and industry relationships to sustain it.

It is today a global leader in premium low-carbon steel, supplying materials to electric vehicle platforms in North America, to offshore wind farms in Southeast Asia, and to infrastructure development projects across Africa. Europe has improved its industrial standing, and used its leadership and diplomacy to put the global steel sector well on its way towards decarbonisation.

Fortress Europe

Fortress Europe describes a future where the global trade environment is protectionist and other producers move more slowly than the EU to transition to low carbon steel production.

Europe has not abandoned decarbonisation — but it *has* narrowed its focus. Faced with rising geopolitical volatility and uneven global willingness to address climate change, EU policymakers have chosen to defend the integrity of their domestic green transition rather than gamble on global alignment. Steel production has transitioned to low carbon processes protected by high tariffs, but output has fallen and is focussed on the domestic market.

The great unravelling

The world began its journey towards full-blown protectionism in the mid 2020s with the introduction of increased tariffs between the United States, China and other nations.

What started out – in some observers' eyes at least – as political posturing quickly escalated into

an all-out trade war as the US sought to protect its manufacturing base by increasing tariffs for (it seemed at the time) everything, everywhere, all at once. China responded with export restrictions on critical minerals required for the manufacture of cars, semiconductors and weapons. The World Trade Organisation (WTO), hindered by America's continued belief that it acted against US interests, was powerless to intervene.

Multilateralism eroded as trading partners aligned with one or other side. High tariffs and technology export controls were used to restrict access to the clean technologies that could support the transition if they were not produced or manufactured locally. Rare earths were, at best, costly and at worst, not for sale.

The post-Cold War vision of an integrated, cooperative global economy unravelled and was replaced by an adversarial, politically constrained global system in which trust, transparency and open access had melted away.

Cooperation on climate change fared no better. Action remained almost entirely unilateral. While a populist US administration opposed the transition on ideological grounds, large emerging economies saw steel decarbonisation as too costly and risky due to weak global demand for clean steel products and did little more than impose nominal carbon prices that were token gestures towards the transition.

For European policy makers – still with high ambition around climate change – the implications were clear: Europe could not rely on global markets to be conducive to decarbonisation and would have to do the hard work on its own. Trade defences and tariffs would be necessary to prevent the EU's steel industry from being undercut whilst it transitioned. If Europe was to both reach net zero and retain strategic control over the materials and technologies underpinning the transition, it would have to internalise the risk, invest in technology development and drive change forwards as fast as it could.

How far that change might go was uncertain. To say the least.

No time to lose

There was no time to lose and Brussels moved swiftly with a raft of pragmatic internally-focussed policies - the European Green Industrial Compact - to catalyse decarbonisation. Chief among these were carbon contracts for difference (CCfDs), financial instruments designed to limit risk in long-term investments in clean hydrogen and low-carbon steel production. These policies effectively guaranteed a minimum carbon price to industrial producers adopting green technologies, unlocking a wave of investment in hydrogen-based steel production.

The Carbon Border Adjustment Mechanism (CBAM), originally an emissions-based tariff, was extended beyond goods to cover a wider range of industrial inputs, deepened to include embedded emissions across value chains, and bolstered by additional tariffs and safeguards. The primary ambition - to protect European producers as they decarbonised – proved largely successful, but only at the cost of significantly constraining trade between Europe and the rest of the world.

These protective measures were not, however, applied indiscriminately. Europe used them strategically and succeeded in negotiating special terms for critical supply lines such as iron ore from Australia, Brazil and Canada.

EU member states — often slow to act in concert — pulled together in the face of an external

hostile environment to coordinate subsidies, regulatory frameworks and just transition programmes across the bloc. Investment rose.

Less production, lower output, lower carbon... but for what?

The EU produces less steel in 2035 than it did a decade ago — but over half is produced by low carbon processes. Production is centred in the Nordic countries and Iberia and supported by manufacturing in Central and Eastern Europe. Legacy blast furnaces have been phased out or converted, and electric arc furnaces — powered by renewables or fed with clean hydrogen iron — dominate the production landscape. Scrap recycling has been restructured around new internal collection and processing networks.

Exports are limited, of course. The rest of the world has no desire for expensive low-carbon European steel, and in any case, other countries have reacted to the EU's CBAM and tariffs with import controls of their own. Instead, European steel flows into domestic infrastructure, automotive and defence procurement pipelines, supported by national industrial policies that emphasise local content, security of supply and emissions compliance.

A difficult hand

Geopolitics has dealt the EU a difficult hand – and in some ways it has played it well. Its industrial strategy aims to restore sovereign production capacity, reduce dependence on volatile international markets, and ensure that green materials are available to strategic sectors without the need to rely on imports from countries with weaker climate standards.

It is working so far, at least for the European industry. But there are dark clouds on the horizon. Not everyone celebrates the EU's continued pursuit of net zero in isolation from other, worse, emitters. Since global emissions remain high, the EU's strategic objective of limiting climate change risks has not been achieved, and critics like to ask what the point of the EU's unilateral decarbonisation has been.

Global steel emissions continue to rise. Continuing global tensions continue to affect global resource security. Relations with other steel making countries and with energy suppliers are worsening. The lack of export opportunities (in steel and elsewhere in the economy) continue to constrain trade and returns on investment.

The strategy appears politically secure for now. The big question, though, is which way those dark clouds are moving. And how fast.

Managed Decline

Managed Decline describes a future where the global trade environment is protectionist and where other producers move faster than the EU to transition to low carbon steel production.

Other regions have taken advantage of abundant low-cost renewable power to stake out leadership positions in clean steel and have put up their own trade barriers to prevent imports of high-emission steel. Europe has struggled to follow due to inefficiency, limited investment and uneven standards, which have ensured the sector's strategic vulnerability. Europe still has a steel industry, but largely due to political intervention rather than industrial transformation.

Challenging times

The early 2020s were a challenging time for Europe.

Russia's war on Ukraine created instability and deep uncertainty about how to secure peace on Europe's borders. The Israel-Gaza conflict led to rising tensions in the Middle East and disruption of global oil markets. Hostile cyberattacks exploited vulnerabilities in critical infrastructure. Global migration rose dramatically, driven by climate change, regional conflicts and economic failure in Africa and the Middle East. In 2025, the Doomsday clock moved forward to 89 seconds before midnight – the closest (at that time) it had ever been.

Faced with such uncertainty – and a fractured NATO alliance - Europe's governments had little choice but to increase spending on defence and security. To this day, defence continues to attract more funding and more talent than other sectors.

The early 2020s were challenging at home, too. Green policies became politically contentious as populations became concerned that the economic advantages were flowing to other countries. Rising unemployment caused by AI and automation sparked anger and protest from a labour force that claimed employers were more concerned with profit than with social responsibility. Structural problems - such as the growing pension and health burden caused by the ageing population and the growing skills shortages in key economic sectors - were serious concerns that regional governments struggled to address.

Europe could perhaps have overcome these challenges if member states had agreed a coordinated response - but faced with political fragmentation and populist pressures at home they chose to revert to national-level social and industrial policies.

Competitive manoeuvring

They weren't alone. As governments across the world focussed on putting their own houses in order, international relationships began to weaken. Rather than working through challenges together, the larger, more powerful global actors began to act as disruptors, changing quotas and tariffs - without negotiation – to enhance their own competitiveness and preferring to maintain the *status quo* of a contested and unregulated trade system rather than seek its resolution. It was an effective strategy that played well with domestic audiences.

Steel was an early casualty of Europe's fragmentation. Other major producers, notably those in China and the Middle East, took advantage of abundant low-cost renewable power and the EU's relinquishing of leadership to establish highly competitive clean steel production. They used subsidies to avoid any risks to competitiveness, enabling their industries to produce clean steel for export as well as for domestic consumption.

Meanwhile, the EU's efforts to invest in the clean power, hydrogen infrastructure, cross-border electricity grid upgrades and clean steel innovations it needed became snarled up in political disagreements between members states, regulatory disputes, drawn-out permitting processes and competitive lawsuits about what qualified for state aid.

The Commission's efforts to pull everything together were valiant but ultimately doomed. No matter what it did, one party always wanted – or objected to someone else's - exemptions and carve-outs. Moving forwards became practically unworkable. As a result, the EU's energy prices remained far higher than other countries, and open competition became a major risk.

Political leaders, eager to protect jobs, demanded state aid rules be relaxed and began to pour subsidies into their own industries - not to support decarbonisation, but to prevent mass closures. The strategy worked for the larger states. Smaller states were not so lucky.

The EU now finds itself with an ageing steel industry: partially decarbonised, heavily subsidised, and largely uncompetitive on global markets. Export volumes have collapsed. Domestic demand is met, but at inflated costs which means that strategic sectors such as automotive, defence and some manufacturing are losing competitiveness.

Delaying the inevitable

The impact on emissions has been stark. Delays in project permitting, hydrogen supply bottlenecks, and political resistance to plant closures have left the EU way off its decarbonisation trajectory.

Where once the EU feared 'carbon leakage' - an adverse effect on its industrial competitiveness arising from being a first-mover in the transition – it now finds itself dealing with late-mover risk. The relocation of investment is increasingly redistributing global steel production. Chinese producers have become even more dominant. Other multinational steel companies have shifted their investment towards the Middle East, India, and Southeast Asia. Several producers have shifted capital expenditure to the United States, enticed by generous subsidies maintained by Congress, anxious about jobs in their own states despite the gutting of other elements of the Inflation Reduction Act.

The steel industry remains important to the bloc's security and, for the time being, is protected by Europe's leaders. This is good in the short term, but it is an open secret that protection is only delaying the inevitable. The industry is now using outdated technology. Governments cannot subsidise production forever and the only strategic choice is whether to hold out for as long as possible or cut and run. Governments have chosen the former – for now - but the decision is under constant review.

In light of this, it is hardly surprising that the sector (despite being classed as a strategic industry) also sees innovation and skills development as a cost to be avoided. The number of jobs remains high, certainly, but the level of skill is declining and the efficiency and performance of the sector is, like its own future, in managed decline.

Slipstreaming

Slipstreaming describes a future where the global trade environment is open and other producers move faster than the EU to transition to low-carbon steel production.

The global steel industry is in the midst of structural transformation, driven by rapid innovation and cost declines in clean steel technologies. Europe has fallen behind, held back by strategic hesitation, disjointed national policies and slow execution. The sector has made the bold strategic decision to enter a licensing partnership with China to access the technological systems and services that Europe needs to decarbonise.

A wave of alignment

International trade relationships got a little rocky for a while during the mid 2020s – but what

started out as sabre-rattling between major trade blocs soon settled down as world leaders took fright at the risks of inflation and financial instability.

China and the US – seeking to move on from a tariff war that neither really wanted or needed – agreed to stabilise tariffs at relatively low levels. Responding to the unpredictability of US policy, the EU, Mercosur, China, and the countries of the Trans-Pacific Partnership moved to secure deeper trade relationships with each other.

Meanwhile, rapid innovation transformed the landscape of industrial decarbonisation. Ongoing development of solar photovoltaics saw their costs continue to fall by 80% in a decade. Combined with breakthroughs in electrolyser chemistry, this led to green hydrogen DRI steelmaking becoming close to cost-competitive against blast furnaces and gas-DRI in the countries with the best solar resources, such as the Middle East, Brazil, and Australia, as well as China. Molten oxide electrolysis emerged as an even lower-cost steel production technology in the late 2020s, prompting a new wave of industrial restructuring, relocation and retirement of old assets.

Too much talk

At the policy level, the EU seemed ready to take advantage of the new regime. The European Green Deal had laid the groundwork, and early pilot projects in Sweden, Germany and Spain showed technical promise. But as global demand for low-carbon steel rose, Europe paused, caught up by bureaucracy - permitting delays and planning disputes slowed infrastructure rollout for hydrogen pipelines and renewable energy integration - and political disagreements about the right strategic approach - priorities for early action, timelines, technical standards, subsidies.

Investors, uncertain about long-term policy clarity, reallocated capital. “There was too much talk and too little action,” the head of one European infrastructure fund famously said at the time. “We needed deals and cheap power. So we moved on.”

Forging ahead

It wasn’t only the investors who moved on. So did some steel producers who, frustrated by the bloc’s failure to capture opportunity, shifted their focus to overseas markets. The few companies in Sweden, the Netherlands, and Germany that had developed early expertise in hydrogen-based DRI, electric arc furnace retrofits and digital traceability began to relocate production to the US and elsewhere. For them, the future looks good.

It's becoming less certain for those left behind. For some domestic manufacturers — particularly in the auto and appliance sectors — cheap, clean steel from abroad has boosted competitiveness and the decline of the EU’s steel sector is no great loss to them. Those with strong ties to legacy steelmakers are, however, more exposed as the sector continues to lose market share, investment appeal and political leverage. Europe’s lack of competitiveness in manufacturing clean technologies doesn’t help.

European governments increasingly see maintaining large-scale steel production in their countries as impossible and unnecessary, and most have chosen to embrace low-cost imports of low-emission materials and goods as an opportunity to increase productivity across the economy whilst meeting their climate goals.

The steel companies that remain believe they can operate in the new market conditions – those early decarbonisation pilots delivered proven results; Europe still has a (partial) hydrogen

infrastructure in place; and, critically, it still has a highly skilled workforce – but they also know that they have to move quickly if they want to survive. They know, too, that Europe remains increasingly reliant on others' technology, having failed to invest in innovation itself.

And so, Europe's steel sector has made a bold decision to enter a licensing partnership with China to access the technological systems and services that it needs to produce competitive, high-quality zero-emission steel. It's a high risk strategy and it's not clear how it might play out. But it offers the potential reward of allowing European steelmaking to continue to supply small but high-value niche markets. The Chinese industry has the technical expertise that Europe needs and, in return, can be given increased access to the European market.

It might just work – but European governments need to put their disagreements aside and work alongside the industry to ensure that any deals remain fair.

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